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Lay Advice

IT is too bad that engineers will not listen to lay advice. How much better, how much cheaper work would be done if only the public's counsel were sought and heeded. After the Quebec Bridge span had gone into the river, while the lobby of the Château Frontenac buzzed with explanation and conjecture, one intelligent-looking layman suggested a plan that solved all the difficulties. He would build the floor system on barges, hoist that to the bridge level and "there put on the upper iron work." We have all met laymen who on the first trip over a line—on the observation platform—saw where a straight road could have been laid instead of the fool curves used by the engineers.

Winter Concreting

AT the approach of cold weather each year it has become a practice to warn constructors against the dangers which attend the placing of concrete when the temperature is low. To most of the readers of the Engineering Record the warning is unnecessary. Without doubt, however, there are men under their direction whose appreciation of the dangers is less keen. It is rather in the expectation that they will be reminded to pass the information along to their employees that the periodical warnings appear. That they have had a good influence is apparent to those who follow the failure reports winter after winter. They were fewer last year than before. If all in authority and influence will convey to those less well informed admonitions similar to those which were published in this journal last week, page 319, the failures will continue to decrease in number.

"Human" Society Publications

ENGINEERING SOCIETIES are giving much attention at present to their publications. In general, they are very prosaic documents. There are brief, lifeless minutes of meetings, a formal announcement of future programs, various official notices and then the text of papers which have been presented at recent meetings. The human touch is lacking. One looks through them from a sense of duty. Their advent never receives a warm welcome. Here and there a journal is breaking away from the "cut and dried" model — which only shows that a human document can be produced from the data available in technical societies. The difficulty lies in a slavish following of custom and in intrusting the proceedings solely to a secretary or other officer who has passed the springtime of life and to whom no new event is novel. Publicity is the young man's field. He sees the novel side of each new happening. He glows over incidents toward which the older man is cold. He grows enthusiastic where the other is conservative. He probably has not the maturity and judgment to qualify him to edit professional papers. On the other hand, the staid editor will lack that human sympathy which is necessary to make a journal that appeals to its readers. Most societies could to advantage supplement their editor with a young assistant whose business it would be to put the human touch into their publications.

A Good Example

AN EXAMPLE of what is meant by the "human" touch in society proceedings will be helpful in connection with the brief discussion of the preceding paragraph. The August *Journal* of the American Society of Mechanical Engineers indicates what can be done. First there are the papers presented at meetings of the society. (And be it noted that those deemed of lesser importance are published in abstract, not in full.) Then follows the "society affairs" section. There is running comment on past and coming meetings. It is easy to read—in marked contrast with the usual minutes and programs. A two-column article tells about the decision of the American Society of Civil Engineers to move to the Engineering Societies Building. Its very title is a welcome to the civil engineers, while the text shows much enthusiasm over the coming of the senior body. Short paragraphs on various matters of society interest then lead to a long—and be it noted, illustrated — biography of Ambrose Swasey, who established the Engineering Foundation. The reports from sections are letters, not minutes, each one a little human document telling of the triumphs, the plans, and the hopes of the sections reporting. They are interesting and inspiring. And so the *Journal* runs. Even its necrology is devoid of the formality that usually hedges in society proceedings. No one needs to be told that the editors of the *Journal* have initiative and the milk of human kindness. Their work is sufficient evidence.

A Year in an Active Society

REFERENCE has been made at intervals in these columns to the excellent publicity work of the Cleveland Engineering Society. That, it goes without saying, is not the only, nor the most important, part of the society's activities. In all its affairs it has displayed a virility of which its publicity work has been the outward sign. Those who are actively engaged and interested in the development of the full possibilities of the local engineering society are referred to the annual report of the Cleveland society, which appears in the July number of its *Journal*. Each committee tells its own story, and the stories are well worth reading. The faith and fiber of the organization are shown by these words of the president-elect: "For that building (a home for the society) we want $200,000, and we are going to get it."

Effects of Building Vibration

WHILE the evidence desired from owners and engineers regarding the effects of vibration of buildings upon the occupants, machines and output and upon the structures themselves is evidently difficult to obtain, at least enough has been collected and published in preliminary form to indicate qualitative, if not quantitative, values. The abstract given on page 355 of this issue reveals some conflict of opinion, combined with a lack of exact data, which suggests that all engineers who can aid in furnishing such facts as are requested should submit them for the benefit of the profession. Undoubtedly some of the effects of vibration are merely psychological and difficult to measure, yet none the less real. The designing engineer is directly interested in those methods of design or materials of construction which will reduce all vibration to a minimum, and an increase in the available information on this subject should be encouraged.

Enterprise and Low Bids

ON March 20, 1915, thirty-eight bids, ranging from $270,290 to $633,690, were opened for rebuilding the 4000-ft. bridge of the Cumberland Valley Railroad at Harrisburg, Pa., described on page 340 of this issue. Practically every bid was from a well-known contractor. The price named for the chief item, 56,000 cu. yd. of concrete arch superstructure, with cement, reinforcing and anchor bolts furnished f.o.b. the job by the railroad, ranged from that of $4.73 per cubic yard submitted by the successful bidder to more than $10 per cubic yard. The estimated cost of the work, including materials furnished and work done in building the substructure and removing the old steel by the railroad, was $750,000. The letting was therefore pointed out by one of our contemporaries as a foolish mistake that would ruin the misguided contractor who submitted the low bid, and insure a very poor job for the railroad. On two visits to the work by a representative of this journal, however, both after the back of the job had been broken and trains were running over the new structure, no complaints were heard either of the contractor losing money or of the railroad getting poor work. The job is so evidently first class and the contractor's executives are so far from contemplating suicide that it is manifest that if a foolish mistake has been made someone besides the railroad and the contractor made it. It is the old story of enterprise and efficiency versus guesswork. The contractor knew exactly what was to be done and how it was going to be done. Indeed, his bid was not so criminally low in the first place, as several others were within a few per cent of it. Instead of loading the contract down with expensive equipment, the work was planned so that it could be done at the specified rate with a remarkably small outlay for plant. The concrete materials were conveyed from cars to form without human handling, and the only power equipment to touch any yard of it was one crane and one gasoline dinkey. Arch forms were devised that did not take a week to move and set up, that were in no danger from floods and that could be adjusted without fuss to both lengths of span required. A type of trestle was provided that gave three tracks in the space usually provided for one, that left 65-ft. clear openings for drift and that could be built and torn down in about the time it takes to look at a framed and bolted structure. The work was arranged so that only enough of this trestle to cross one channel was needed. The I-beams in it alone, but for an unusual flood last spring, would have netted the contractor 150 per cent profit at the end of the job through the increased price of steel. Even as it is, there certainly will not be a loss. No lumber, plant or material that might be good for anything when the job is done has been made up so as to lessen its salvage value. Who can say that bidding of this sort is not good business, or that the contractor with sufficient enterprise to carry it through is not contributing to the progress of construction by contract?

Bay State Railway Decision

BOTH encouraging and discouraging points are to be found in the decision of the Massachusetts Public Service Commission in the Bay State Street Railway case, abstracted on page 342. Although the commission denies the railway company the right to increase its fares to six cents, it turns a deaf ear to some of the plaints of those opposed to the rate increase and shows a disposition to give the company a fighting chance to earn a fair return. For example, the commission does not wholly condemn the company for following the practice common in times gone by of declaring dividends before setting aside a depreciation reserve, nor does it accept the theory that, despite the fact that the company's dividends have in the main been inadequate, deductions should be made for plant paid for out of earnings. And right here it might be pointed out once more to those who see in every investment out of earnings past robbing of the public through excessive profits that many a conservative management has turned back into its property money that could have been dispersed in dividends without swelling them beyond reason.

The commission finds some objection to the estimate method of obtaining original cost, which is the basis of value that obtains in Massachusetts. Advocates of the reproduction basis give as one valid objection to original cost the impossibility of obtaining it accurately in most cases. While the Engineering Record believes reproduction cost, which more nearly represents present value, is preferable in any case, it believes that the estimate method of finding original cost is likely for old properties to be more accurate than the historical method. Certainly the latter is not free from the charge of giving an impression of accuracy not warranted.

The Engineering Record is not sufficiently conversant with the Bay State railway's past to comment on the rejection of claims for intangible values, except to repeat two arguments that seem to it conclusive against treating development expenses as something to be made up by a few years of extra earnings. One is that it constitutes a forced withdrawal of capital, the other that it imposes on the generation of the public that can least afford it a burden for the sole benefit of those who come later. The limiting by the commission of all overhead allowances to 8 per cent seems, however, to clash squarely with experience. The engineers who built the Bay State Street railway must have been foresighted and fortunate indeed if they were able to escape with contingencies less than the 3.23 per cent asked by the company's appraisers, and neither do the other percentages look excessive. In fact, it would appear at this distance that the 12.74 per cent asked by the company was extremely conservative.

Better Utilization of Coal

MORE THAN ONCE the Engineering Record has called attention to the importance of investigating the low-temperature carbonization of coal as a method of conserving our wasted natural resources in fuel. No inconsiderable amount of work has already been accomplished abroad on the solution of this urgent problem, and a recent publication by Prof. H. E. Armstrong forcibly brings to the front the whole situation and emphasizes the lamentable waste now going on. In Great Britain five-sixths of the coal mined is for one purpose or another burned directly, while only from the remaining sixth are the valuable by-products extracted.

It is in the utilization of by-products that modern industry excels, and it is in close attention to avoiding waste that success lies in many branches of industrial work. Professor Armstrong notes with pungent emphasis that while much of the initial work on the low-temperature carbonization of coal was carried out in Great Britain, works for the operation of the process on a commercial scale are still building there, while at least ten similar establishments have been put into operation in Germany, yielding a great supply of necessary raw material for high explosives. If all the bituminous coal capable of successful coking were thus treated an important supply of liquid fuel for internal-combustion engines would be made available; there would be a huge quantity of the crude material for dyestuffs—enough from Great Britain alone to supply the whole world; ample amounts of ammoniacal products for agricultural uses, a vast volume of gas for all sorts of domestic and manufacturing needs, and finally an immense store of coke suitable for all heating purposes, including the highly effective and smokeless operation of steam plants.

To-day, in this country as elsewhere, we are burning up, at small thermal gain, products which amount in value to a large percentage in the price of the raw material. We are lowering the general thermal efficiency of the utilization of the remainder and encouraging the production of smoke instead of suppressing it. We are only beginning to appreciate the vital importance of the chemical industries based on the distillation of coal. The conditions brought on by the present war have been a valuable if costly lesson which should be taken to heart and not forgotten the moment peace brings the resumption of commerce.

Professor Armstrong goes so far as to urge legislation by the British government forbidding the use of raw coal and thus compelling the economic improvements here referred to. Such measures would probably be denounced here as the last degree of paternalism, entirely contravening the spirit of American institutions—which may be summarized briefly in the terms of the old proverb, "Everyone for himself and the devil take the hindmost." But Great Britain has learned some terribly practical lessons on government in the stress of war, and stranger things would happen than some drastic regulations to enforce long neglected economies. The subject is one which ought to be taken up very seriously in industrial circles here, that America may not be left behind in the impending struggle for manufacturing supremacy.

Another Quebec Bridge Disaster

NINE YEARS AGO the engineering public was shocked by the news of disaster to America's greatest structural project—the Quebec Bridge. While still remembered, the event had been dimmed by time, and more so by the confident hope that a still greater structure, although of the same span, would this season successfully bring to a conclusion the expectations of many years. The hope has been dashed. The suspended span, which was to have been erected by a novel method, lies at the bottom of the St. Lawrence. The unparalleled anchor spans and cantilever arms remain standing unscathed, after being put to a most severe test.

The story of what happened—recital of fact—is told in the news section of this issue. The suspended span erected on shore was to be towed to the bridge site and hoisted from the supporting scows to the track level, 150 ft. above. The raising of the 5200-ton load on the scows was successfully accomplished. The 3-mile trip to the site was made without incident and on schedule time. The connection of the span to the hoisting chains, considered the critical feature of the work, was successfully made. The operation of the hoisting jacks and the falling tide soon freed the scows. They were withdrawn, and for an hour and a half, during which the span was raised in at least seven successive 2-ft. lifts, the huge structure hung free from the cantilever arms, all apparently going exactly as planned.

Then without warning the span slipped into the river, carrying with it, some to their death, the workers on it.

Facts have not been developed which allow the cause of the disaster to be satisfactorily explained. A careful examination of the lifting girders and chains has given no clue. It is doubtful whether we will ever know the initial cause of the failure. The girders and their chains still hang from the cantilever arms. Two of the girders—those that carried the southeast and the northwest corners of the suspended span—make an angle with the horizontal, but that fact is readily explained by the knowledge of how the span went into the river. The hoisting equipment is in perfect condition save for the rupture of piping connections between the jacking platforms and the ends of the cantilever consequent upon the shock. In some way the span slipped from its supporting stirrups. At present, therefore, and possibly for all time, we can only theorize as to the initial cause. Various theories have been proposed and various explanations offered. They can only be weighed with respect to their relative degrees of probability. Facts to test them, to confirm them, to refute them are missing.

First, the theory may be dismissed as least plausible that a main member of the suspended-span trusses failed, and that the slippage from the stirrups followed thereon. While at Sillery Cove, the point of erection, the span had rested on the very supports on which it was being hoisted. Moreover, while so resting it had in place a temporary construction track which was removed before flotation, and also carried a heavy locomotive crane. As a simple span, therefore, it had been stressed higher than while it was being raised from the river.

While, then, the possibility of failure not superinduced by other causes may quickly be dismissed, somewhat more consideration might, were it not for direct confuting evidence, be given to the theory that a difference in elevation of the two corners at one end, combined with a lack of stiffness from the erection standpoint, caused the lateral system to draw two or more main-truss members out of line. But the evidence is indisputable that the two shoes at each end were at the same elevation within a sixteenth of an inch. That theory must, therefore, be dismissed as untenable.

The explanation that would at first hearing seem most likely—that the southwest lifting girder was pulled from its proper place by an extraneous force—must be dismissed as lacking supporting evidence. In fact, the evidence on this head is directly against any such theory. Not more than twenty minutes before the span slipped a very careful examination of all mooring lines was completed and all were found, as they should have been, in slack condition. What rise there was in the intervening minutes slackened the lines still more. Furthermore the removal of the lifting girder would have required a very considerable force. The load on each corner was theoretically 2,600,000 lb., and at present there is no reason for supposing the load distribution to be otherwise. At 5 per cent the force to overcome the friction was 130,000 lb. In addition, plates and lugs added somewhat to the resistance.

The most plausible explanation of the failure is that the casting intermediate between the two pins on the lifting girder on the southwest corner broke. This casting, in fact the whole of this universal supporting shoe at each corner, as well as the lifting girders, carried heavier loads at Sillery Cove, where the span was erected, than during the hoisting operation. Suspicion is directed at the castings only through a process of elimination. Forgings and rolled sections are more reliable than castings, in which concealed flaws are always possible. Furthermore, probably every other detail of the structure and of the hoisting mechanism is more determinate as to calculation than these castings. The shape of the intermediate casting is clearly shown in the drawings and photographs accompanying the article in this issue. While apparently ample in design so that the stresses, as well as judgment can dictate, are conservative, the shape is such that a flaw in one of the wings might allow a crack to start at the root. Total failure would readily result from such an initial crack.

Now that the accident has occurred, it is easy to suggest that the shoes might better have been built of rolled sections and plate; that the bearings, instead of being in semi-cylindrical halves, might have been pin holes; that some auxiliary support might have been provided to supplement the main supporting detail. But the best judgment of the best bridge engineers on this continent said that the detail was sufficient—amply sufficient—for the intended service. Something went wrong, but it was not through lack of ability of those responsible for the work, nor can it be said that the castings were not tested before use. They were tested—and under greater loads than they were presumably carrying when the crash came—for they supported the span at Sillery.

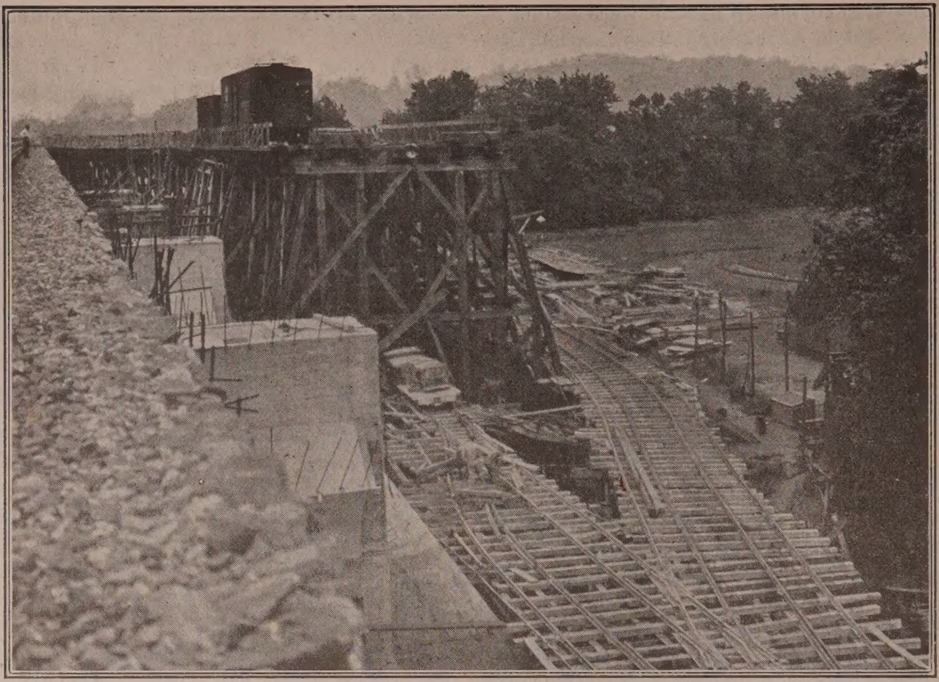
It is natural to look for some inducing cause—even if the breakage of a casting is accepted as the most reasonable explanation—some swaying of the structure, induced by a puff of wind, the unequal working of the jacks, etc. Suffice it to say that there is no evidence of such an inducing cause. No freshening of the wind—which was very light—was felt. The jacks were not operating; the structure had been pinned fast for a full two minutes before the drop came. Vibration from cranes or hoists on the cantilever arms, if any were working at the time, may be considered negligible.

It will be the hope of the entire engineering profession, even, at this minute, against hope, that facts will be disclosed which will allow the mystery to be cleared up. The method was a great step forward in bridge-erection practice. It was originated and developed by the best bridge-engineering talent on the American continent. Its details were thought out with a minuteness and care that were nothing short of marvelous. Moreover, it worked—yes, we repeat it—it worked, even though the span lies to-day on the bed of the river. From the time the span left Sillery Cove until it dropped into the stream there was no hitch in the program. Every operation save one, the driving of the pins connecting the suspender eyebars of the cantilever arms with the suspended span, had been successfully performed. The remaining moves, except the one just referred to, were repetitions of those already made. All the more reason, therefore, for hoping that the error, the accident—call it what you will—may be analyzed.

The loss of the span, while it may in the lay mind cast discredit on those responsible for the work, in reality put the remaining parts of the structure to a most extraordinary test and so proved the ability of the designers and builders. The suspension of the span from the cantilever arms deflected their ends between 9 and 10 in. The application of the load was gradual. Its release, on the contrary, was sudden. Men on the ends were thrown down, while the vibration lasted long enough for one man to run about 250 ft. toward the anchorage. At least the full deflection must have been recovered, and probably the momentum carried the ends above the normal unloaded position. Yet the cantilevers stood—and apparently undamaged. Furthermore, the known details as to the successive steps in the plunge, combined with the evidence of the two diagonally opposite over-stressed hangers, show that very large overloads must have been thrown into at least the downstream truss on the south cantilever and the upstream truss of the north cantilever. But there is no apparent evidence of distress.

The bridge, which has thus received a setback, for it is only a setback, is extraordinary in so many respects that it is a pity it should not have come through with a clean record. The K-truss design, the marvelous precision and finish of the shopwork, the ingenious and highly successful erection methods—each would have made the structure notable among steel bridges, even though the span were less than the record.

Engineers, who must constantly face unknown factors in breaking new paths, will not lose faith in their brethren at Quebec, though the layman, seeing only the outstanding fact of a second serious loss at the site, may be a doubting Thomas. The men at Quebec will stand by their guns. The loss has only served to set their jaws in a determination to complete the structure, and by the method planned. The stamina shown by these men under the strain of the loss was an inspiration. Backed by their determination and ability, the span will be rebuilt and successfully erected.



ALMOST ALL CONCRETE WORK HANDLED FROM THIS CENTRAL PLANT ON WIDE ISLAND

Little Plant Required to Complete 4000-Foot Concrete Railroad Bridge

Build Greater Part of Two-Track Arch Structure Under Traffic with 2 Cranes, 3 Dinkeys, 1 Concrete Plant, 11 Half-Arch Forms and ⅓ Mile of Trestle

A DOUBLE TRACK concrete arch bridge, four-fifths of a mile in length and containing, above water, 56,000 cu. yd. of concrete is being built in longitudinal halves by methods which require the use of a very small amount of equipment. The bridge, which is at Harrisburg, Pa., replaces the old single-track deck truss bridge of the Cumberland Valley Railroad across the Susquehanna River. Two concrete arches replace each of the old steel spans, which were moved 8½ ft. upstream on the old double-track piers and kept in service while the south half of the new bridge was built. Traffic was then diverted over the new bridge, the old steel taken down and work started on the completion of the north half of the concrete structure. With the exception of two spans on the far side of a railroad embankment west of the river, and of a small yardage of concrete placed by the pneumatic method, all of the work was handled from an island 300 ft. wide in the middle of the river.

The small amount of construction plant used is accounted for by the way in which the contractor took advantage of circumstances to develop the work. Briefly outlined, the method followed was to throw 1600 ft. of trestle across the west branch of the river, downstream from the bridge, and carry the new work from it west and toward the island. As fast as the centers could be removed from the westerly arch spans, the trestle was taken up and replaced from the island outward across the east channel. The completion of the work over this channel enabled the railroad to divert traffic over the new structure, as noted in the Engineering Record for Feb. 12, 1916, page 229. The construction trestle was then taken up and stored on the island for the winter while the old steel spans were removed. It was then built out again across the east channel, but on the upstream side of the bridge. The upstream half of the new structure is now being built in the same way as the first half, except that the work is being carried from east to west.

Steel arch centers of one size are used for both the lengths of arch span encountered in the work. These centers are supported on brackets set in niches formed out of the piers, doing away with falsework supports for them. Also, a type of trestle is used which has a high salvage value and which provides three running tracks with four rails.

CONCRETE MATERIALS HANDLED BY GRAVITY

The main concrete plant, located in the middle of the island on the upstream side of the bridge, receives all materials by rail. The level of the old bridge being considerably above the island, it was easy to arrange under a trestle turnout from the main line stone and sand bins with a capacity of 150 tons and a cement shed holding about 200 bbl. Sand and stone are delivered in hopper-bottom cars, and cement is dropped down a wood chute to the level of the charging platform. Directly under the partition between the sand and stone bins are located three measuring hoppers which empty into a ½-yd. Haines mixer suspended over the track for the concrete cars. Two of the hoppers are for measuring stone, one being filled as the other is emptied, and the third is for sand. It was planned to install two mixers, but as one proved able to turn out concrete at 35 yd. an hour—as fast as it was necessary to place it—the second was never used. Five batches fill two 1¼-yd. buckets on a platform car, which is handled by a gasoline locomotive. Three of these units are kept going between the mixer and the crane which places the concrete in the forms.

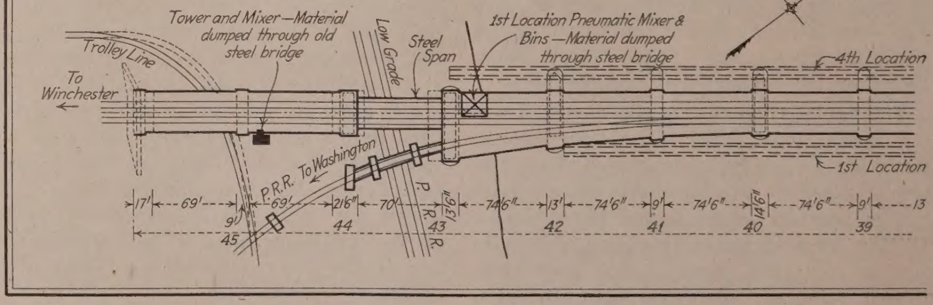
TRESTLE WITH HIGH SALVAGE VALUE

The type of trestle developed on this work provides three tracks with four rails, the inside track standard and the outside tracks 3-ft. gage. The same type was used in building the Philadelphia & Reading Railroad bridge at Milton, Pa., and was described in the Engineering Record of May 20, 1916, pages 676 and 686. The trestle at Harrisburg differs from that at Milton in that pile driving is not required in its construction. The rock bottom is exposed over most of the channel, and timber posts, cut to lengths determined by sounding with a rod, placed and capped by a gang working from a small barge, were used instead of piles. Some trouble was experienced with this trestle because the rock bottom afforded no anchorage and because the river was subject to floods which produced a strong current at the island. On the other hand, it would have been hard to find a way of carrying on construction without some temporary work in the river. A severe flood on June 18 carried out the entire trestle shortly after it had been erected in its third location, and bent most of the steel stringers around the upstream ends of the piers. The stringers were straightened and the trestle was rebuilt, however, in a very short time.

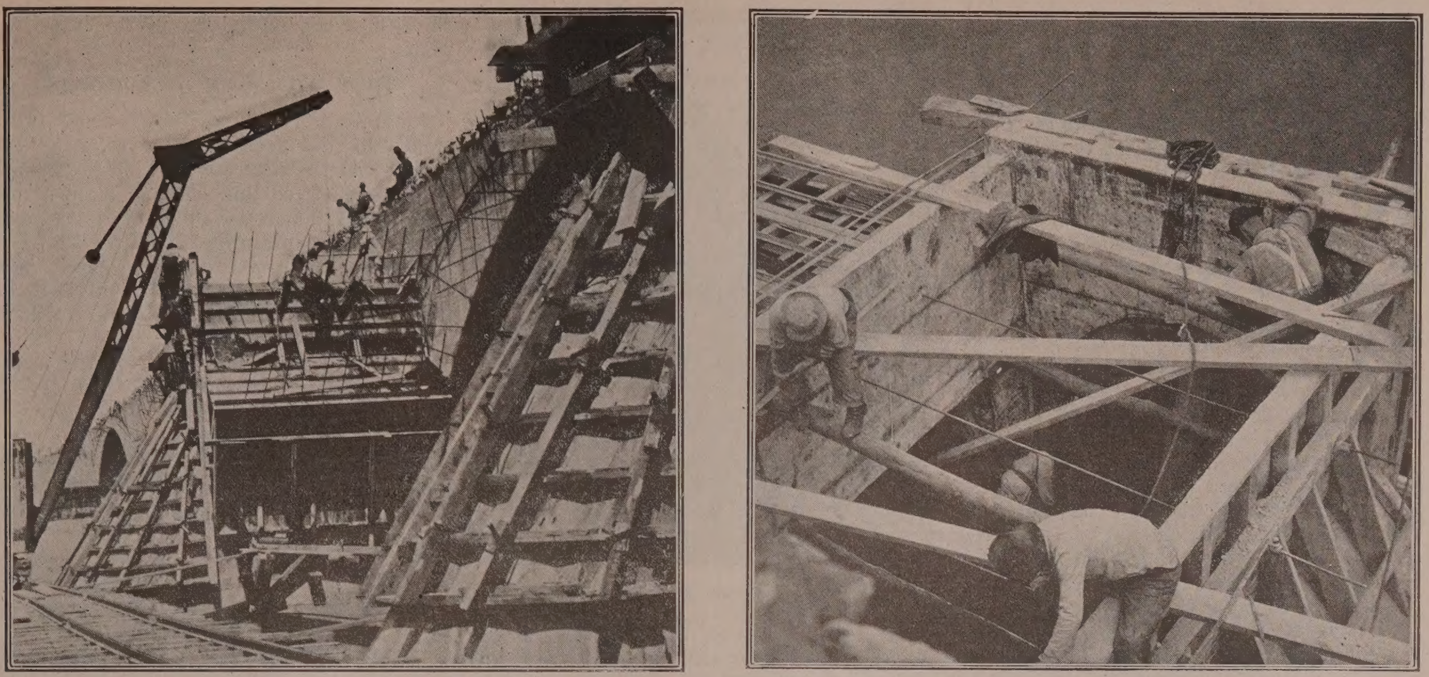
The track arrangements on the island are shown in the accompanying drawing. It will be seen that the use of three trains and a crossover between the narrow-gage tracks on the island made it possible to supply concrete to the crane on first one and then the other of the outside tracks without having any temporary crossover at the point of work.

OLD PIERS UTILIZED

The fact that the river was wide and shallow, with a bare rock bottom, made pier construction simple. The old masonry piers were incased in reinforced concrete to a point above water level and the new



TRESTLE USED IN FOUR LOCATIONS TO MOVE FORMS, HANDLE CONCRETE AND DO PRACTICALLY



UMBRELLA FORMS LINED WITH STEEL AND CONCRETED BY CRANE WHOSE "GOOSENECK" BOOM WAS DESIGNED TO REACH OVER CORNERS

piers built to the same level in the fall of 1914 by the forces of the railroad company. The following winter the old steel spans were moved 8½ ft. north, and in the spring of 1914 the work of completing the intermediate piers was carried on by the contractor with the construction of the south half arches. All of the pier work was carried up to the spring line of the arches during the 1915 season, but the umbrella sections for the upstream half arches were not touched until this year.

ONE LENGTH ARCH FORM FOR TWO LENGTHS OF SPAN

The umbrella sections are concreted before setting the arch centers, and the spandrel walls cast after the arch concrete has set, but generally before the centering is removed, as the specifications require that this be left in place 30 days. Finally the coping, which contains the conduits for telegraph and signal wires, is concreted separately. By employing on the main river section ten sets of half-arch centers, six sets of umbrella forms, six sets of spandrel wall and four sets of coping forms it is possible to keep the concrete plant at work almost continuously.

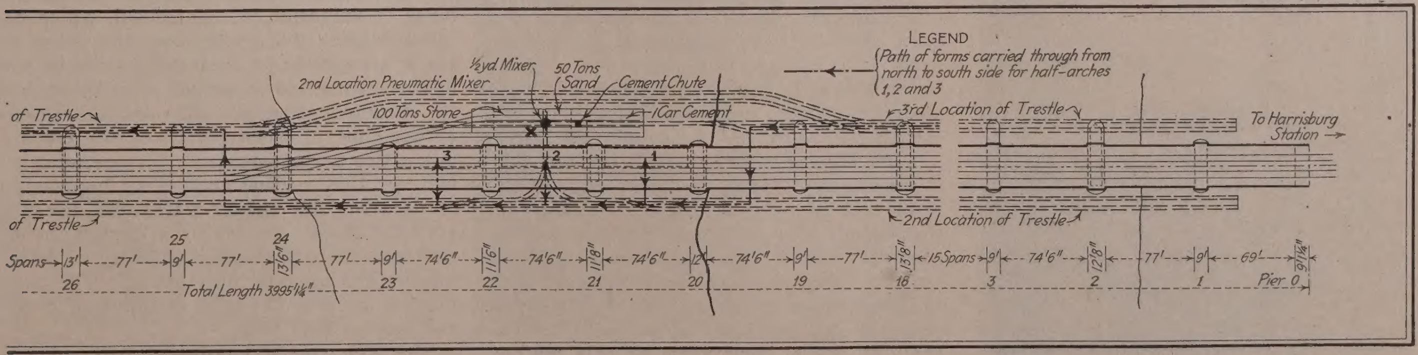
The construction of the arch centering, which is of the three-hinged type with four trusses, tied across the bottom for moving by turnbuckle rods, is shown in the photographs. As it was desirable to use the arch forms in direct rotation, all were made the same size. For the 74½-ft. arches the circle strips that support the lagging rest directly on the top flanges of the arch ribs. For the 77-ft. spans these strips are blocked up from the ribs. Black sheets of No. 24 gage are used for arch lagging. They rest on a double layer of 2 x 8-in. plank spiked transversely to the circle strips. The planks overlap, but are laid with a 1-in. space between pieces in each layer. Every fourth or fifth strip is bolted through. The 2-in. material was used because of the fact that it has a much higher salvage value than the 4-in. which was used at first. It is also easier to work with.

No chances were taken with the river in the support of this centering. Four steel brackets to each end of each arch, set in recesses formed in the sides of the piers, are used. On these brackets parallel to the pier are set 12-in. timbers carrying the rollers used to move the forms sidewise into position from the trestle. As soon as a form is placed it is wedged up to grade, and is later struck by knocking out those wedges and letting it down again on to the rollers. Four trucks running on the outside trestle tracks are used to transport the centers lengthwise of the bridge. During the first season when the steel bridge was in place the centers were, of course, handled on the downstream side. At the end of the season all ten of them were left for the winter under the last spans concreted at the east end of the bridge. At the beginning of the present season they were rolled through to the north side and used for the upstream halves of the same arches, which were the first ones concreted this year.

The road bed on the bridge is carried by a stone fill resting directly on the arches. This fill is retained by the outside spandrel walls; but as the south half of the bridge was put in service before the other half was built, a center spandrel wall extending to within 18 in. of the base of rail was also necessary. The pockets produced by this construction over the arch haunches are drained by 6-in. pipes extending through the arch concrete just above the umbrella section.

OLD STEEL REMOVED AND MATERIAL TRACK SHIFTED IN WINTER

A locomotive crane began last winter to take down the old steel from the east end. As the old spans were about 160 ft. long, they were supported on falsework and taken down a panel at a time from east to west. One of them near the center of the east channel had been about half removed in this way when the flood early last April, on which the ice went out, carried away the falsework and dropped the remaining half into the river. This steel will be cut up at extreme low water with the oxy-acetylene torch and removed from the work trestle.

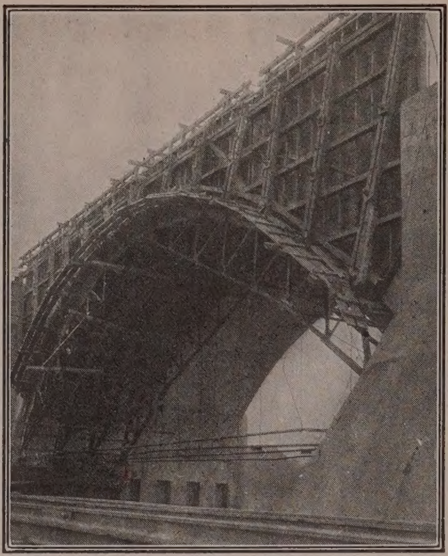


ALL WORK ABOVE WATER ON 56,000-YARD CONCRETE BRIDGE PROVIDES THREE TRACKS WITH FOUR RAILS AND HAS HIGH SALVAGE VALUE

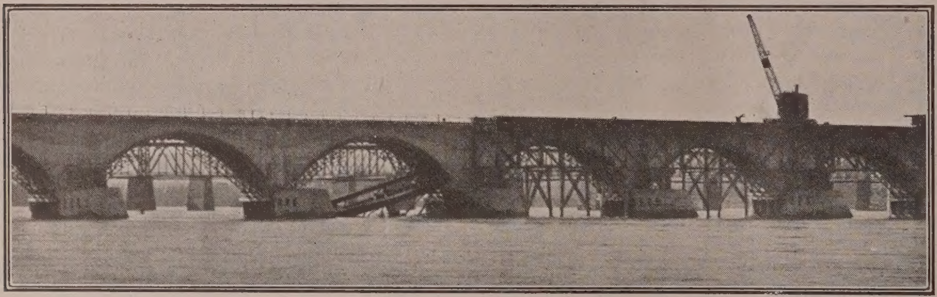
When the removal of the old steel had progressed past the concrete plant on the island, the trestle connecting the latter with the old main line was rebuilt and a turnout put in the track over the new bridge. When the removal of the old steel bridge was completed, the crane used for this purpose was employed to concrete arches and piers on the island which could not be reached by the gooseneck crane on the track below because of the material trestle being in the way.

Routing of Forms in Crossing Island

The moves to be made with the arch forms in crossing the island for the second time were carefully mapped out because access from the north to all of the arch spans across the island except one span at each side is blocked by the concrete plant and trestle. Three of the forms released from the east end of the bridge were brought up, slipped through the span at the east end of the island to the south side of the bridge, rolled along opposite three of the arches to which access from the north was blocked by the concrete plant, moved sidewise through these arches to the north side and concreted. Meanwhile the remaining eight forms were used to complete the spans across the east branch of the river. These forms are being rolled around the north side of the concrete plant and started in again at the west shore of the island.



RIBS WEDGED UP ON BRACKET SUPPORTS



SOUTH HALF COMPLETED, RIVER EXTENDS UNSOLICITED HELP TO CRANE IN REMOVING OLD STEEL

The forms used on the island will be taken to the west edge, rolled through to the north side and put to work again in regular rotation with the other forms.

This maneuvering leaves one north half arch at the west end of the concrete plant unfinished. This arch is blocked by the trestle turnout. Its completion will be the last work done on the bridge. After everything else is finished, enough material to concrete this span will be stored in the bins, the trestle turnout removed, and one arch center brought back to this location and concreted.

ARCH FORMS MOVED ON TRUCKS

The extreme west end of the bridge consists of a concrete-incased girder span, not included in the general contract, crossing the low-level tracks of the Baltimore division of the Pennsylvania Railroad, which is on a high fill at the river bank, and of two arch spans beyond. As concrete could not be carried across the Pennsylvania tracks, a separate plant, supplied with materials dumped from the old steel bridge, was set up. This plant consisted of a ½-yd. Smith mixer, a short steel tower and a spouting system. Also wood centers were used for these half arches. The centering for the extreme easterly arch span, 69 ft. long, which crosses a road in the park along the east bank of the river, was cut down from a set of 74 ft. 6 in. centering used for one span on the island. When this centering had been used to concrete the north half of the extreme east span, it was trucked across the river and used to complete the two 69-ft. spans beyond the Pennsylvania tracks. These spans, of course, could not be finished until the old steelwork had been removed.

A pneumatic concrete plant, erected near the spouting plant on the west bank of the river and later set up for a short time on the island, was also used for part of the concrete work across the west channel. On account of the trouble encountered with the high velocity of discharge in placing concrete on the arch slopes and in the spandrel walls, concreting by this method was not experimented with long enough to reduce its cost to figures comparable with the cost of concrete placed by the other two plants.

Bridge Will Soon Be Completed

In spite of the six weeks' delay occasioned by the flood referred to, it is expected that the concrete work on the bridge will be completed this season. Arch forms are usually concreted in eight hours, and one of them, containing 275 cu. yd. and distant 1000 ft. from the mixing plant, was completed in 7½ hours. On Sept. 1, 16 of the north half arches had been finished, leaving 29 to be completed.

The bridge is being built for the Cumberland Valley Railroad, of which T. B. Kennedy is chief engineer, under the direction of Crosby Tappan, engineer of construction. A. F. Byers is chief inspector and S. F. Bloyer resident engineer for the railroad. The work is being done by the Robert Grace Contracting Company, for which F. P. Kemon is in charge as superintendent under B. R. Hundley, eastern manager.

Commission Doubts Accuracy of Estimated Original Cost

Massachusetts Decision, Denying Bay State Street Railway Six-Cent Fare, Discusses Numerous Valuation Problems

DENYING the Bay State Street Railway of Boston the right to increase its fare to 6 cents, the Massachusetts Public Service Commission, in a decision rendered Aug. 31, expressed opinions on various points pertaining to valuation and fair return on investment. The commission thinks a 6 per cent return should be ample for the company. It holds that a fair return should be allowed on all the capital properly invested, without deduction of accrued depreciation, and believes that the company should not be condemned too severely for following in the past the common custom of declaring dividends without making allowances for depreciation. On the other hand, it holds that from now on depreciation should take precedence over dividends, even though for a while the stockholders should suffer a complete suspension of admittedly inadequate returns. Other views of the commission are that development expenses should be made up by additional earnings for a few years, and that 8 per cent is ample for all overhead expenses in this particular case.

Estimated Original Cost

The decision discusses the valuation of the property made by Sloan, Huddle, Feustel & Freeman, consulting engineers for the company. As Massachusetts has established original cost new as the proper basis of valuation, the appraisal, which totaled $42,987,405, embracing 957 miles of track, was made on that basis—not by the historical method of actual investment, but by the application of estimated unit prices at the time of construction to the present quantities as inventoried. The commission believes this method creates an impression of accuracy not wholly warranted, because of the difficulty of making a correct inventory and the still greater difficulty of determining the original unit prices. The commission reduces the total estimate of original cost by $600,000.

The company's engineers had allowed overhead charges, which were estimated, of 12.74 per cent of the direct property cost, dividing it as follows: Engineering and superintendence, 3.68 per cent; interest during construction, 2.23 per cent; taxes during construction, 0.12 per cent; insurance, 0.48 per cent; organization and legal expenses, 3 per cent; and contingencies, 3.23 per cent. The commission found from appraisals submitted in thirty capitalization cases from 1890 to 1900 an average of only 2.19 per cent for engineering and superintendence in the case of roadbed, track and overhead system, and nothing in the case of other items. The commission realizes the probability that much overhead expense has not in the past been segregated, but believes, nevertheless, that the estimate exceeds the reality. Contingencies also, the commission believes, have been overestimated. Consequently the allowance for overhead expenses is reduced to 8 per cent—a reduction of $1,822,344.

No evidence was introduced by the company to substantiate its claim of intangible property, embracing reward for promoters' services, cost of securing plant and cost of development. The first claim was that a certain amount of overcapitalization was necessary to reward the promoters and attract capital. The commission avers, however, that most of the "watering" was done during the electrifying of the lines, long after the promoters' stage, the promoters apparently having sought their reward in construction contracts and enhanced land values. Development expenses, in the opinion of the commission, should be charged to earnings—opportunity being given to spread them over a reasonable period of years, but not indefinitely.

The commission rules that no deduction shall be made for accrued depreciation. While the commission does not commend the paying of dividends before a reserve has been set aside for depreciation, it holds that the company should not be condemned too severely for following a prevailing policy in the past in doing this, especially as even then dividends have averaged less than a fair return. It is pointed out that companies under the Massachusetts laws that are not paying dividends find difficulty to finance their needs. For the future, however, the commission holds that needed repairs and renewals should take precedence over dividends, even though it seem harsh to stockholders already receiving only a meager return. Six per cent, in the opinion of the commission, would be ample.

Tar Patching on Concrete Roads

The Ohio Highway Department in patching concrete roads cautions its maintenance gangs not to apply so much tar that it will stand above the level of the concrete surface. If a mound of tar is placed, the pavement is likely to be shattered beyond the mound from the drop of vehicles raised by the patch.

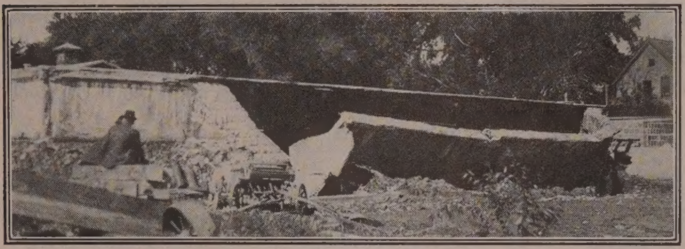
Reservoir Wall Fails When Backfill Is Removed

Faulty Construction at Roof Due to Failure of City Officials to Put on Inspector Said to Be Contributing Cause

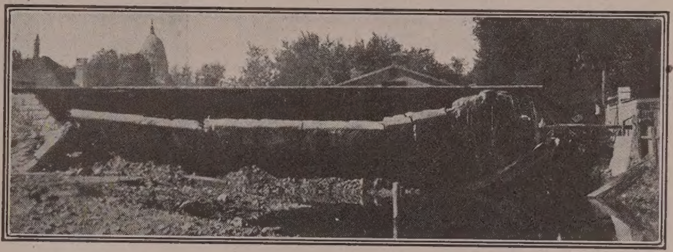
On Aug. 26 the 1,000,000-gal. reservoir constructed by the city of Madison, Wis., in 1906, of reinforced concrete, rectangular in plan, about 100x116 ft., partly failed. The reservoir is 16 ft. in depth and has a reinforced concrete roof. Against the outside walls of the reservoir is an earthfill extending up to about 10 ft. above the base. The walls of the reservoir were designed as a simple vertical reinforced beam, supported in part by the earth embankment and in part by the connections at the roof. The specifications called for the reinforcing rods of the roof to be hooked around the vertical reinforcing rods of the walls, but no specific method of doing this was shown on the drawings, the horizontal rods simply extending about 18 in. into the top of the vertical wall.

FUNDS FOR INSPECTION REFUSED

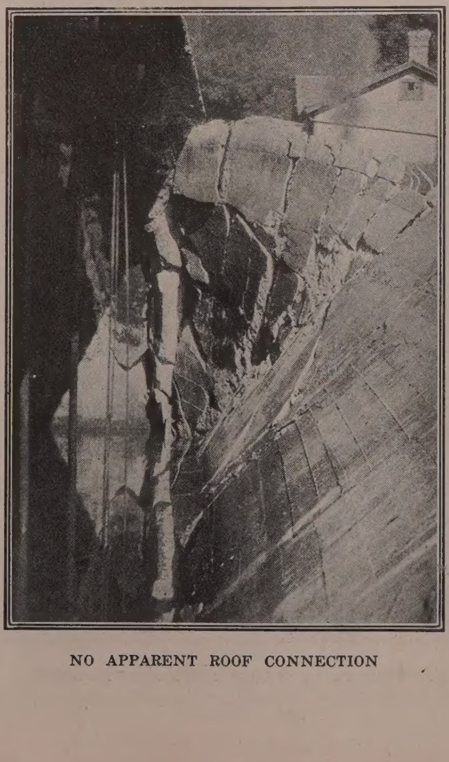
The city refused to provide funds for an inspector during the construction, as was desired by the engineer who drew the plans, and in consequence the engineer had no further connection with the work. Apparently no attempt was made to carry out this feature of the specifications, and as a result the stability of the wall of the reservoir depended almost entirely on the backfill of 10 ft. of earth on the outside. Signs of failure by the slight yielding of the wall in places had been noticed five years ago, but were not thought to be serious, as the cracks formed thereby did not increase further in size, and the embankment alone appeared to give sufficient stability. The roof was also slightly cracked in several places, and to prevent infiltration of rainwater an additional cover was put on the reservoir.



THIN RESERVOIR WALL ROTATED OUTWARD ON ITS BASE



WALL DID NOT BREAK UP MUCH DUE TO ESCAPING WATER



NO APPARENT ROOF CONNECTION

UNFAMILIARITY WITH CONDITIONS CAUSE OF FAILURE

In 1916 plans were made to build another reservoir of 15,000,000 gal. capacity immediately adjoining the one already built. The engineer planning the new reservoir and also the engineer in charge of the city water department were evidently unfamiliar with the weakness of the old reservoir as regards the roof connections, and using caution which would have been ample for ordinary cases proceeded to remove a part of the backfilling. The result was that on Aug. 26, with a length of about 15 ft. of the backfilling removed along one side adjoining the corner, about 60 ft. of the side wall of the reservoir failed, tipping about the base as a center. The results are plainly shown by the photographs.

Engineers who have examined the circumstances and the wreck state the best lesson to be learned from the failure is that the engineer in making plans for reinforced-concrete structures must insist on retaining full control of inspection until the structure is completed.

Unwatering Holland's Overflowed Lands

In the early part of this year an exceptionally heavy storm broke the dikes on the coast of the Zuider Zee and 50,000 acres of valuable land was flooded. The ground surface was about 4 ft. below the level of mean tide. The unwatering was accomplished by means of pumps manufactured by the Werkspoor Company of Amsterdam. These were assisted by the pumping plants which normally take care of the drainage. The temporary plants had a capacity of 120,000 tons of water per hour. With the exception of one, which was driven by a Diesel engine, they were all electrically propelled, current being furnished by the municipal electric works at Amsterdam. With this equipment, assisted, as before stated, by the regular pumping installation, the area was unwatered in a little more than three weeks. The *Engineer*, from which these notes are taken, states that the same part of the country was flooded in 1825, and that it took from February of that year to July of the following year to get rid of the water, all of the pumping being done with the aid of windmills. All in all, including the building of the pumps and their installation, this year's unwatering was accomplished in less than four months from the time of disaster.

Wind Damages Highway Bridge

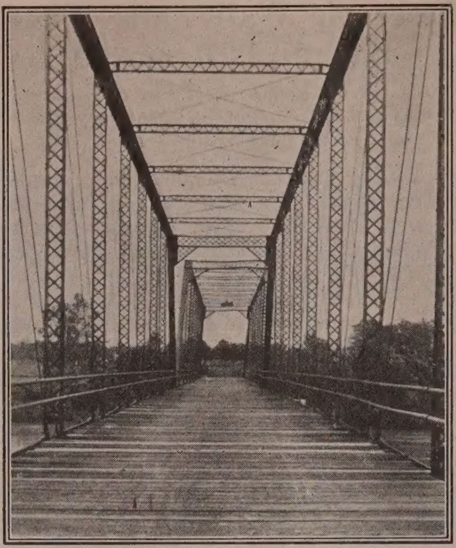
Tornado Nearly Overturns Sugar Island Structure in Illinois — Portals Badly Distorted and Lower-Chord Eyebars Buckled

AS A RESULT of the destructive storm on March 21, a steel bridge over the Kankakee River, known as the Sugar Island bridge, was considerably distorted; in fact, it was nearly wrecked. The Iroquois County bridge was completely destroyed by the same storm. Damages to both bridges have been described in *Illinois Highways*. In the July issue Clifford Older, bridge engineer of the Illinois Highway Department, discusses the damages to the Sugar Island bridge. The following abstract from his article describes particularly the effect of the wind on the portals, lower chords and masonry of the west span, which was most injured.

The bridge consists of two spans, each 185 ft. long center to center of end pins. The steel trusses are of the Pratt type, 26 ft. high and placed 17 ft. 2 in. apart. The exact date this bridge was erected could not be determined at the time examination was made. The details and general character of the design are typical of highway-bridge construction common about 15 years ago.

DISPLACEMENT OF UPPER LATERAL SYSTEM

One of the photographs shows the trusses of the west span leaning decidedly toward the north. The east span was not so badly damaged, but it also has an inclination in the same direction. It is evident that the wind was blowing in a northerly direction. The top chords, although displaced laterally, were found to be in perfect alignment, and the top lateral truss and diagonals were practically undamaged. It is evident that the top lateral systems served, as intended, to carry the wind load to the portals. The latter, however, proved to be too weak to transmit, without damage, the accumulated top-chord wind load down the end posts to the foundation.



VIEW LOOKING WEST SHOWS TRUSSES OF FAR SPAN LEANING TOWARD NORTH

The condition of the west portal of the west span is shown in one of the photographs. It is interesting to observe that the distortion of the portal occurred largely in the part between the kneebraces. The lacing bars were flat and connected by one rivet at each intersection. They buckled in the compression system and some of the bars in the tension system were pulled apart.

It seems evident that, provided a no more serious weakness developed elsewhere, complete failure of the portals would have been caused by a slightly greater wind load and the tipping over of the trusses and complete collapse of the spans would have followed the failure of the portals.

LOWER LATERAL SYSTEM

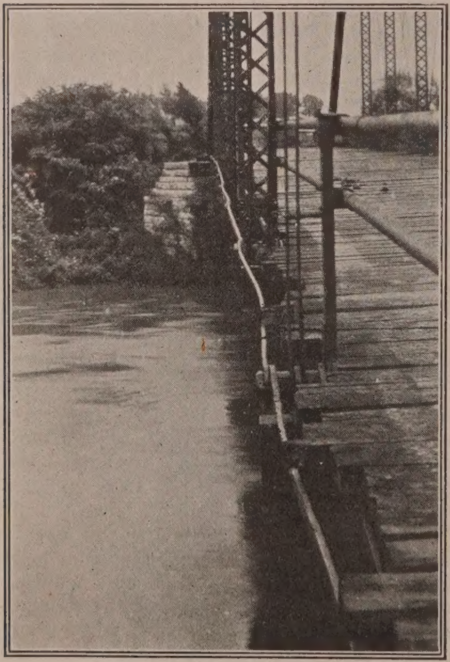
A partial failure of the lower lateral system of each span occurred—in the case of the west span, even had the portals and top lateral system held, complete failure was imminent because of the weakness of the lower lateral system. The lower chords of the trusses, as well as the floorbeams and lateral rods, are, of course, an essential part of this system. The lower chords are composed of eyebars throughout the entire length of the span. The lateral rods are round, passed through holes near the end of the floorbeam and in bent plates riveted through the floorbeam webs on the far side. The ends of the rods are threaded and provided with nuts.

One of the diagonals was subjected to compression during this storm, and pushed through the holes of the floorbeam and connection plate until the nut was 1 in. or more away from the bent plates. As in the case of the upper laterals, the tension diagonals did not fail, although the bent plates were somewhat distorted by the pressure of the nuts and the rods were probably slightly overstressed. Partial failure of the system occurred because of the reversal of the dead-load stress in the lower-chord bars on the windward side of the bridge. The lower chords, although displaced laterally, were found to be in perfect alignment from the second-panel point at one end to the second-panel point at the opposite end of each truss.

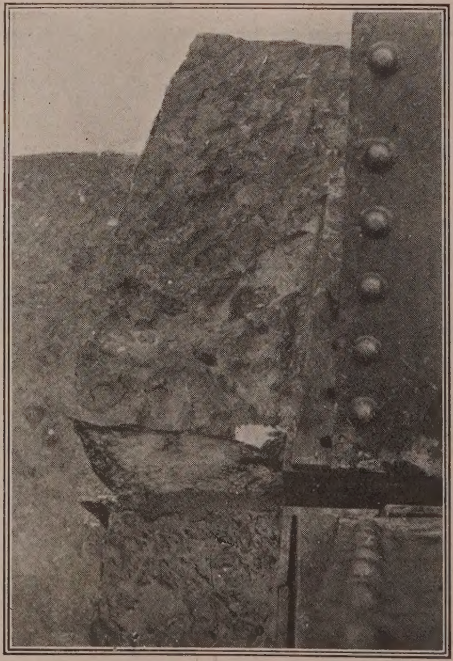
MASONRY STONES DISPLACED

It is evident that the wind force brought to the shoes in excess of that necessary to overcome the horizontal component of the dead-load thrust of the end posts would have a tendency to pull the shoes off the foundations. This excess stress was sufficient to displace the stones on which the shoes rest at the pier. The movement of the upper ends of the end posts would also tend to rotate the shoes and probably aid in this displacement. It is doubtful if much uplift occurred, because of the lack of sway-bracing and the failure of the portals. No hinged bolsters were provided, but rollers were in place under the pier shoes. This expansion device appears to have been sufficiently serviceable to have permitted a recovery movement of the lower end of the end posts when the wind load was released, limited, however, by the length of the slotted holes through which the anchor bolts passed. The final position of one of the anchor bolts with respect to the slotted hole in the shoe is shown in one of the photographs.

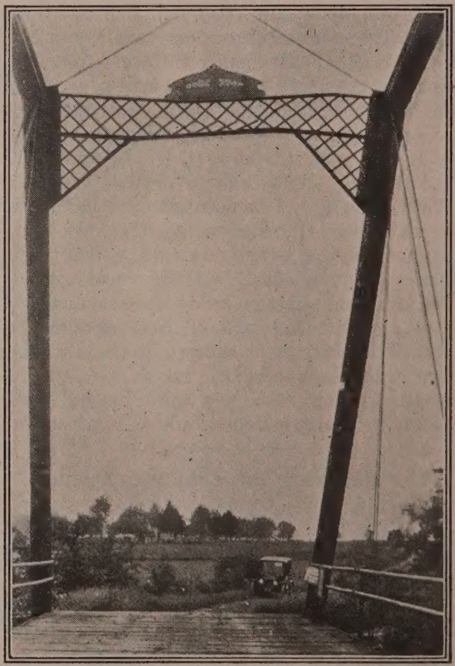
The horizontal component of the dead-load stress in the end posts was not sufficient to



LOWER CHORD BARS BENT IN END PANELS



MOVEMENT OF SHOES DISPLACED MASONRY



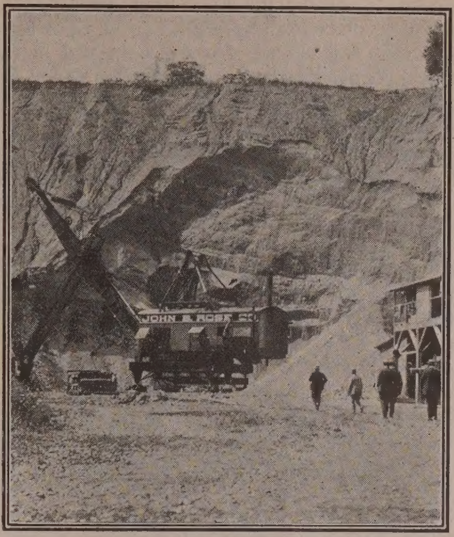
WEST PORTAL OF WEST SPAN BADLY DISTORTED push the shoes back to place after the wind subsided. Neglecting uplift, this would lead to the conclusion that the total wind force applied to the shoes during the storm must have been more than double the horizontal component of the dead-load stress in the end posts. Approximate computations seem to indicate that the wind pressure per linear foot of lower chord must have been in excess of 220 lb. The present specifications of the Illinois Highway Department require that a wind load of 300 lb. per foot should be provided for in the plane of the lower chord and 150 lb. in the plane of the upper chord. These specifications also stipulate that the lower chords, as well as all other members, must be composed of shapes capable of resisting compression as well as tension.

Giant Revolving Shovel Used at Gravel Plant

Solves Troubles with 150-Foot Face in Pit by Cutting 85 Feet from Base—Feeds Mechanical Crushing and Loading Plant

A GRAVEL PIT with a working face 150 to 175 ft. high which, in spite of careful blasting and hand trimming, was subject to frequent slides that buried the railroad shovel employed and shut down the entire plant, is now being worked with safety and speed by a 3½-yd. Bucyrus revolving shovel of the double-track type that has been used extensively in stripping coal mines. The plant, that of the John B. Rose Company on the Hudson River at Marlborough, N. Y., produces sand and crushed gravel. The material is handled from the screen on which the shovel deposits it by a system of conveyors through the crushers, washers, sand separators and screens to the bins and storage piles, from which the loading belt and two underground conveyors which feed it draw material to be loaded in cars of the West Shore Railroad or to be carried across the railroad to barges at the loading dock.

The large revolving shovels themselves are something of a novelty, having been designed to remove 30 to 40 ft. of overburden from coal seams and cast it so far at the first handling that a strip of coal 112 ft. wide could be exposed by operating from one line of track. It is said that this is the second one of these shovels to be employed for another purpose than coal stripping, the first having been installed a short time ago in a similar gravel pit in the central states. With its great reach, this shovel dispenses with transportation from the pit to the belt supplying the crushing plant. At intervals of several months or a year this belt can be extended as the shovel progresses. The big machine, which can reach the toe of the bank from a distance of 85 ft., has nothing to fear from slides, especially as the material is not stiff enough for a perfectly vertical face to develop. The shovel is operated with a full-circle swing. By not reversing to dump, both power and time are saved, and the operator can work more easily and quickly.



SHOVEL HANDLES HIGH FACE

SHOVEL INCREASES OUTPUT

Formerly a dragline machine was used to handle material from the railroad shovel to the crusher plant, and a large gang of laborers employed to blast and trim the face. It was difficult with this equipment to keep the plant supplied with 1000 cu. yd. of material a day. The big shovel can easily handle 4000 cu. yd. a day, and its use has cut the force to 15 men, including the shovel crew of 4. The plant, originally designed for an output of 1500 yd. in 10 hours, has been enlarged until it is possible to produce 2500 yd. of marketable materials per 10-hour day. The enlarged plant is to be duplicated, so that the full capacity of the steam shovel may be utilized. Meanwhile, in order to catch up with deliveries, a large number of electric lights, ranging from 40 to 1000 cp., have been installed, and the present plant will be operated day and night.

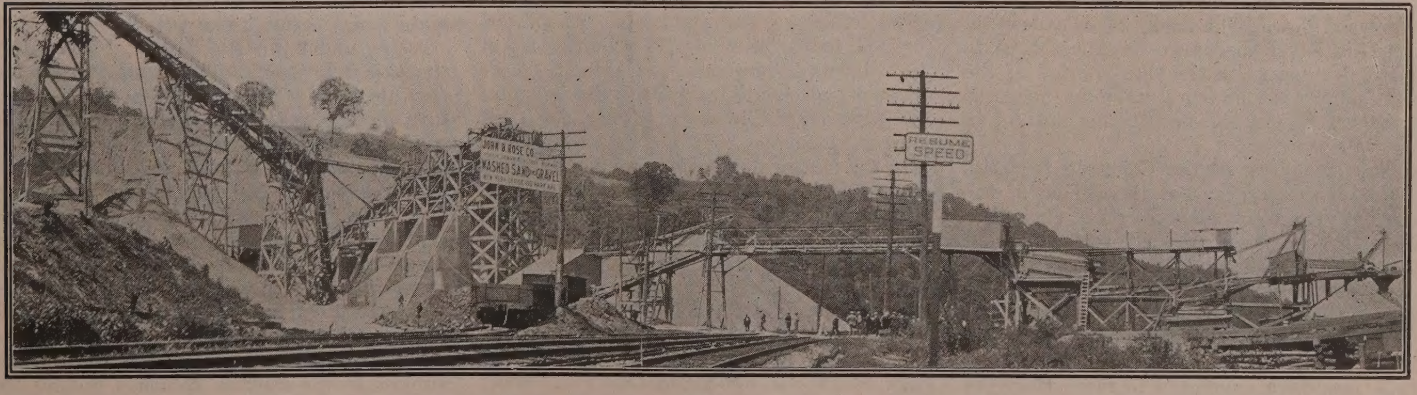
Material is deposited by the shovel on a 1½-in. grizzly screen, all the boulders being mud-capped. About 10 or 12 lb. of dynamite a day is used in this way. From this screen a pan conveyor takes material to the top of the crushing house, where it passes through a bull screen to the main conveying belt. Material rejected by this screen goes to a No. 7 gyratory crusher, from which it passes to a second 1½-in. screen. Material too large for this screen goes to No. 4 twin gyratory crushers, from which is passes to a third 1½-in. screen, rejections from which go back to the pan conveyor. The main conveying belt takes material to twin scrubbers located at the top of a structure over the stone bins. From here it passes through sand separators and successive 1½-in., ¾-in. and ⅝-in. screens, below which are a second and third set of sand separators.

BELT CONVEYORS USED

All sizes of stone are dropped from the screens directly into the concrete bins. The sand is taken up a bucket elevator to a belt conveyor, which carries it to the sand storage pile of 30,000 yd. capacity. The gravel coming from the ⅝-in. screen is taken to a storage pile of the same size by an aerial belt conveyor, 220 ft. long, suspended from cables. These cables are anchored to the top of the concrete bin structure and to a mast set at the far end of the storage pile.

Underground conveyors from each of these storage piles take material to the main loading belt, which is fed from them by an elevator at the river end of the stone bins. This belt itself extends beneath the stone bins, and transports material across the double-track main line to the river, and to sidings on the West Shore Railroad. Material may be diverted into cars by a tripper located over the sidings. At the far end of the loading belt is a washer for cleaning the gravel again before it is loaded. A short conveyor and a spout take material from this washer to the river barges. Under this washer is located the main 10-in. pump which supplies 2000 gal. of water per minute for the plant. The entire plant except the steam shovel is driven electrically with current purchased from the Central Hudson Gas & Electric Company of Newburgh, N. Y.

With the exception of 18 in. of soil at the top, practically none of the material excavated is waste. The gravel is sold along the Hudson River and to a large extent in the New York City market. The ½-in. gravel is used extensively in road surfacing, and the sand is largely employed in making brick at the adjacent yards of the John B. Rose Company and other brick yards on the Hudson River. The sand is also sold for building purposes and for subway construction in New York City. The plant is in charge of George C. Hudson, superintendent for the John B. Rose Company.



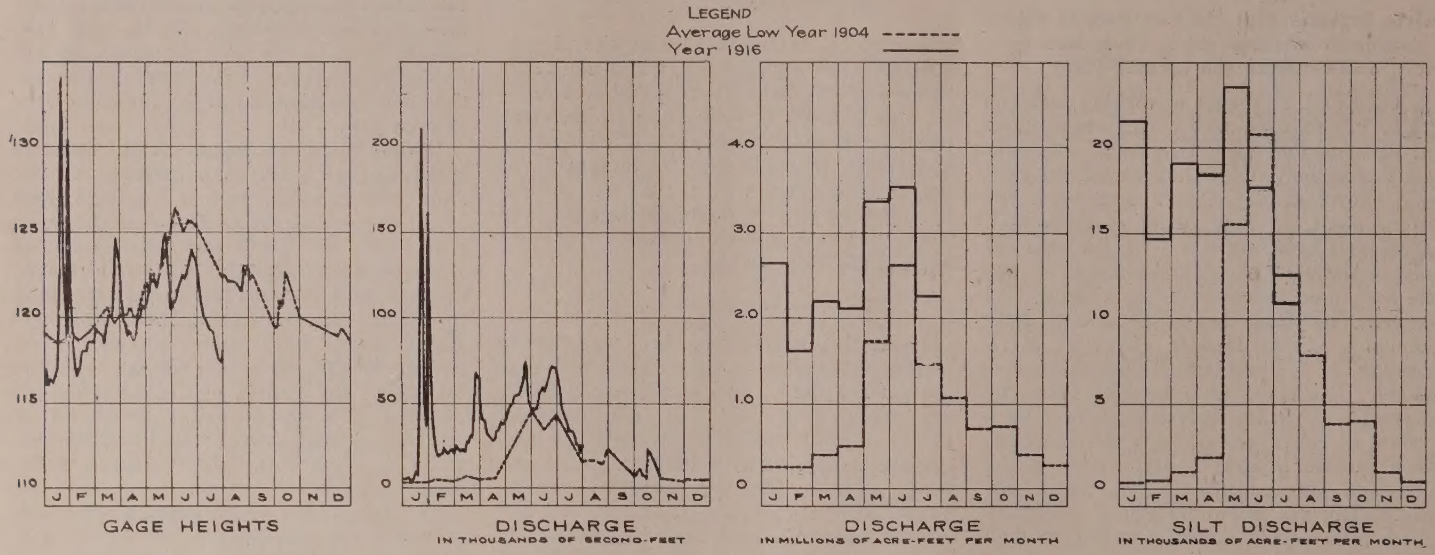
SAND STORAGE AT LEFT, CRUSHER HOUSE AND PIT IN LEFT BACKGROUND, SCREENING PLANT AND STONE BINS LEFT CENTER, FINE GRAVEL STORAGE AND 220-FOOT SUSPENDED CONVEYOR RIGHT CENTER, LOADING BELT AND SPOUT AT RIGHT

Colorado River Conditions This Year Unprecedented

Severe Floods in Lower Sections of Stream Attributed to Discharge of Gila River

By L. M. LAWSON
Project Manager, U. S. Reclamation Service, Yuma, Ariz.

LOWER COLORADO RIVER water conditions for the present year have differed largely from previous records of measurement. The erratic and unprecedented discharge is almost entirely caused by the principal lower river tributary, the Gila River, of Arizona. This stream, with an annual runoff at its mouth in the Colorado just above Yuma varying from zero to 3,000,000 acre-feet, has in previous years, notably 1891 and 1905, augmented the normal discharge of the Colorado to menacing proportions. In fact, all known floods from upper Colorado River sources have been of much less volume and gage height, and consequently less danger to the large irrigated area in Arizona, California, and the Republic of Mexico bordering on the lower river. The section of the river below Yuma, passing through this now large irrigated and heavily producing district, received the full force of the flood waters of both very different drainage areas.



COMPARISON OF COLORADO RIVER DISCHARGE, GAGE HEIGHTS AN D SEDIMENT FOR YEARS 1916 AND 1904

The spring runoff from the melting snows in Wyoming, Colorado and Utah, while occasionally of long duration, has its peak flattened in passing through the long stretch below the Grand Cañon, and the gradual, steady rise permits sufficient scouring and lowering of the sand and silt bed to accommodate without extreme gage height the increased flow. The flashy rises caused by the Gila River discharge have less time to effect deep scour in the short period of the increasing rise, and present much more of a menace to the levee-protection system of the valley lands.

The discharge of the Colorado from its upper drainage area for the period of the present year so far elapsed can be classed as close to normal and the severe flood conditions in the lower river experienced in January and February are attributed to the flow of the Gila. Similar in cause and effect to the floods of 1891 and 1905, precipitation in the region of the upper Gila tributaries in a few days amounted to more than the entire year's normal rainfall. This produced a discharge at Yuma greater in amount, duration and gage height than any previous measured flow. Compared with the discharge from the upper Colorado, its crest was 70,000 sec.-ft. in excess of any measured flood stage.

The gaging station of the U. S. Reclamation Service at Yuma was established in 1903. Previous to that time the only records kept were gage heights, beginning in 1878. Because of the shifting bottom, no accurate estimate of flow can be applied to these river-height observations. A study of the precipitation records of stations in the Gila River drainage shows that the 1891 flood from that source may have equaled in magnitude the 1916 discharge. Table 1 exhibits the comparison between maximum flood runoffs of both drainage areas.

The characteristics of the lower river in the matter of its bed-scouring action are well illustrated by comparing the cross-sections of the low-water period of September, 1915, with the flood measurements of January, 1916 (indicated in Table 2).

In all probability the scour section has been greater at times of other flood discharge. In fact, soundings made during the 1909 Colorado River flood showed a depth of 66 ft. at the Yuma station. This is accounted for by the relatively quick rise of the Gila discharge compared with the more gradual and steady increase in discharge of the flow from the upper Colorado River sources.

TABLE 1—FLOODS IN LOWER COLORADO RIVER AT YUMA GAGING STATION

Date	Gage	Discharge, second-feet	Source
Feb. 27, 1891.	33.2	(not measured)	*Gila River, Ariz.
March 20, 1905	30.3	110,800	Gila River, Ariz.
June 24, 1909..	30.7	149,500	†Upper Colorado River
Jan. 22, 1916	34.0	220,000	Gila River, Ariz.

*Area Gila River drainage, 56,000 square miles.

†Area Colorado River drainage, 169,000 square miles (above mouth of Gila River).

In the matter of changes in river bed it is of interest to note the results of the determination of the river gradient as affected by the change in location from the old route to the Gulf of California and its present course through the Bee River and Volcano Lakes. Beginning in 1909, when the river channel shifted to the Bee River location, and continuing to date, the average of all gage heights is approximately 2 ft. lower than the previous records, notwithstanding the fact that quantities of discharge made no corresponding decrease. The writer is informed that little of the large flow of the January flood found its way down the old channel to the Gulf.

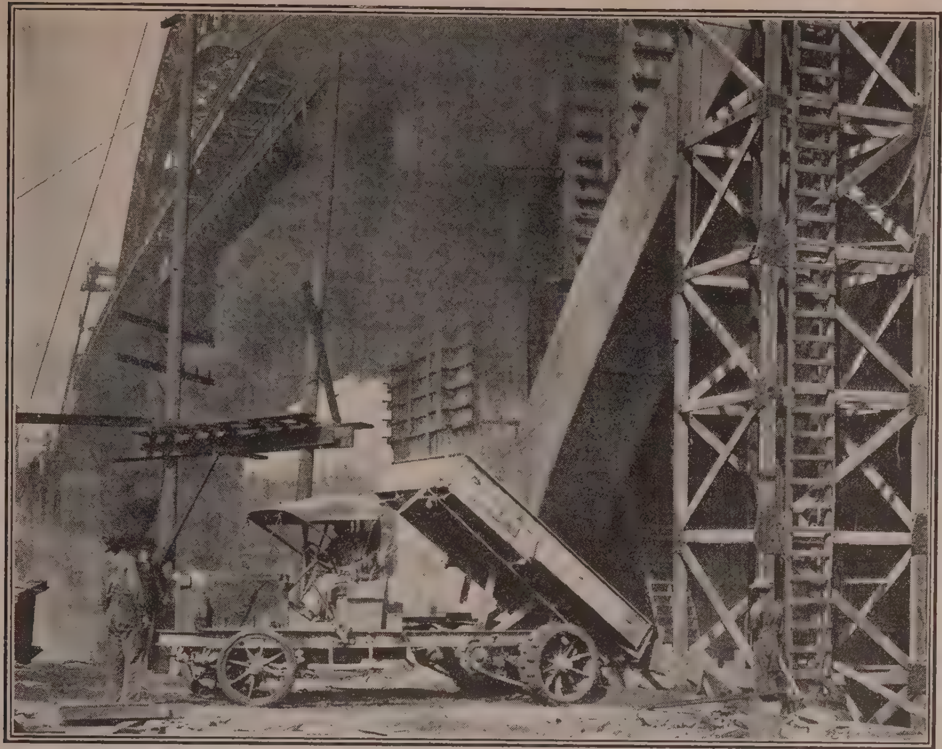
The amount of sediment carried during the past flood stage has been observed and recorded. These observations have been in progress since 1909 and are made triweekly, at times of stream measurement. The percentages by weight vary from 0.04 to 1.26, with the maximum proportion occurring when the discharge is about 25,000 sec.-ft., which represents the bankful stage. During the one month of January, 1916, more than 21,000 acre-feet of silt and sand in suspension passed the Yuma gaging station. The Gila River, with a gradient of more than three times that of the Colorado, contributes when discharging a large amount of the sediment to the lower river.

The effect of this flood condition on the irrigation and protection works of the Yuma project has been reported in this journal. The Laguna dam, located above the mouth of the Gila River, diverts only upper Colorado River water for irrigation purposes of the Yuma project. Provision for sluicing operations and regulator gate control, provided in the construction of the weir, results in the removal of 50 per cent of the heavy sand and silt from the river water. Original plans considered the location of the main canal through the Gila Valley with a crossing under the Gila River. Fortunately the Colorado River siphon was substituted for this plan. The maintenance of a structure of any reasonable length against the wide meanderings and large discharge of the Gila would have been very difficult.

TABLE 2—BED-SCOURING CHARACTERISTICS OF RIVER

Date	Gage	Discharge, sec.-ft.	Area, sq. ft.	Width, ft.	Max. depth ft.
September, 1915	114.5	2,700	1,410	410	6
January, 1916	134.0	220,000	24,000	600	60

The accompanying diagrams of discharge, gage heights and sediment show conditions at the Yuma gaging station for the first seven months of the present year. For comparative purposes the hydrographs of the year 1904, an average year, are also plotted. No record of any year since the station has been maintained is in any way similar to the flow as recorded during the present season.



DUMPING TWO YARDS OF WET CONCRETE INTO HOPPER THAT FEEDS TOWER SKIP

Motor Trucks Distribute Materials Within the Job

Wet Concrete Handled at 20 Cents a Yard Saves Building Second Plant—Possibilities of Truck as Construction Tool Brought Out on Cleveland Bridge

"LET ME PUT my motor truck on the job and I'll cut out this 19-man shovel brigade and put that slag right in the cellar where you want it."

Mr. Mullen, of Masters & Mullen, contractors for the Frederick Building in Cleveland, had been impressing on the speaker, A. D. Bender, secretary of the Cleveland Macadam Company, the urgent necessity for faster deliveries of slag, used on the building as concrete aggregate. The owners of the Frederick Building were in a hurry to occupy it, and in view of that fact the sight of the narrow street, a line-up of teams and nineteen men laboriously shoveling material, was depressing.

They had studied the possibilities of backing up the teams in the street to dump into the cellar, and of arranging to drive them within the lot lines—and the study had increased the depression. Then it was that Mr. Bender played his trump. He had just bought the first back-dumping motor truck in Cleveland—the third truck ever built by the White Company. In making the proposal with which this tale opens he was confident that the truck would save the day.

Mr. Mullen, however, was less sanguine. "You couldn't even get in here with that thing, much less dump and get out," he declared.

He was finally persuaded, however, to cut a hole in the fence and give the despised truck a chance.

An hour later, standing with Mr. Mullen on the same spot, Mr. Bender enjoyed his triumph. The truck, with 6½ yd. of slag, drove into the narrow street, backed up to the fence with ridiculous ease, dumped its load into the cellar and drove out—in less than a minute. Mr. Mullen took one look and departed hastily to put the nineteen shovelers to more productive tasks. Thereafter there was no question of the sufficiency of the slag supply.

Parts of Long Bridge Difficult of Access

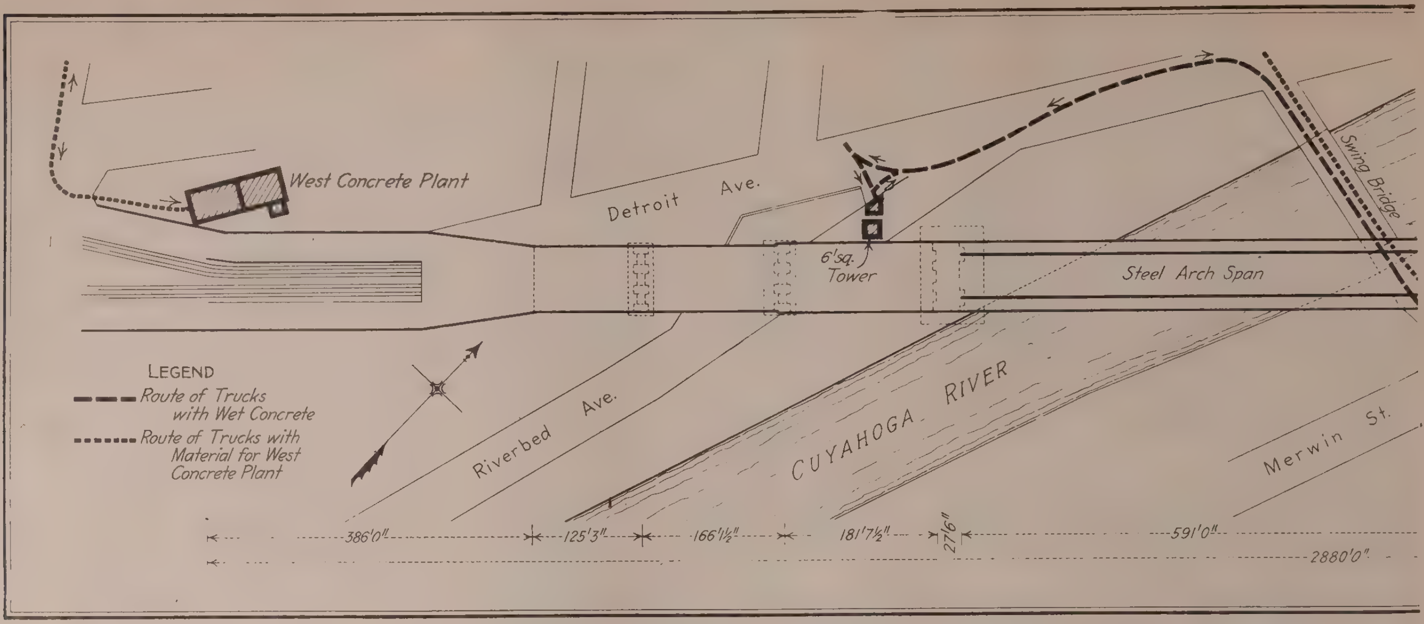
From that day on the possibilities of thus handling materials in large units at high speed have been developed in Cleveland until motor trucks have made easy the building of a $2,500,000 bridge so situated that materials could hardly have been handled on it otherwise without the most elaborate plant. Though the Detroit-Superior viaduct had both water and rail delivery of materials to within the shadow of its arches, yet access to its different parts, built under separate contracts, was made so difficult by facilities in use under and around it that it is doubtful if any mechanical plant could have been designed to obviate handling the construction material by street.

The problem of distributing and placing 63,000 cu. yd. of concrete in the superstructure of a bridge 2880 ft. long would be a large one under any conditions. Moreover, in this case the substructure was let to separate contractors, who had to provide for mixing and placing 45,000 additional cubic yards of concrete. Besides, form lumber, reinforcing and supplies had to be transported. The concrete superstructure was separated into two distinct parts by a navigable river crossed by the main 591-ft. steel span. A railway yard, buildings, a passenger station, several streets and a low-level swing street bridge lie wholly or partly beneath the structure. Though there were both rail and water delivery to within the lines of the bridge, they could be taken advantage of only on one side of the river. The construction trestle, the cableway, the central spouting system and other types of plant could not, singly or in combination, have handled the materials for the entire contract without some connecting link across the river. The only connection available at reasonable expense was over the city streets and the low-level bridge.

Materials Supplied at 60 Tons an Hour

These streets were narrow, steep and by no means smooth. Five years ago no one would have counted on a progress in concreting that meant delivering over their 10-per cent grades 60 tons of material per hour. This speed was necessary in the present case, however, as little storage space could be provided to stock up before each day's concreting, and it was actually maintained by three motor trucks. These units, making a 1-mile round trip from the receiving dock to a concrete plant set at the extreme west end of the bridge, kept up this pace without delay or breakdown while 8000 cu. yd. of concrete was poured from this plant. At the same time other trucks owned by the Cleveland Macadam Company, and one of them the original truck referred

MAIN PLANT, CEMENT SHED IN LEFT FOREGROUND, ONE OF CRANES AT RIGHT



LONG BRIDGE EXTENDING OVER STREETS, BUILDINGS, TRACKS, ANOTHER BRIDGE AND A RAILROAD STATION WAS

to, hauled 500 yd. of slag every 24 hours for a period of two months for the concrete in the river piers. The half-mile haul from the material yard to the piers represented but 12 cents per yard of the cost of this slag delivered.

Trucks in the employ of several other supply firms have hauled cement, sand, stone and supplies continuously from the start of the work for one or another of the contracts. The White Company has estimated that, all told, 44 trucks of its make and some built by other firms have handled materials for this bridge.

TRUCKS DISTRIBUTE CONCRETE

Continuous concreting with limited storage space and handling materials on the job in limited road space have not, however, been the greatest achievements of the motor trucks on this contract. Three of them have supplied concrete from the main mixing plant east of the river for continuous pouring on the west viaduct. The first half of this west viaduct was concreted from the plant mentioned previously, which was on the west edge of the valley level with the roadway of the bridge. While convenient for the first part of the west viaduct, the relocation of this plant in the valley floor would have effected a saving in concreting the last 8000 yd. But a concrete plant was already in operation on the east bank which could be used on the east viaduct only part of the time, because its capacity exceeded the rate at which forms could be got ready. It was to this plant that water and rail deliveries supplied materials direct.

The question arose, if concrete materials from this location could be transported separately fast enough to run a plant continuously on small storage, could not mixed concrete be transported from this plant fast enough to keep a tower and spouting system with no storage in continuous operation?

This idea was put into execution, and a tower whose skip could be filled from a hopper into which trucks could dump wet concrete was located between piers 2 and 3. Thus the building of an additional mixing plant was saved, and the plant already in operation was utilized to capacity.

The last concrete plant, from which all the work is now being handled, consists of a 1-yd. mixer mounted under bins supplied with sand and gravel by bucket elevators, which are fed by two cranes on the river bank. Cement, delivered by rail, is hauled on an automatic dumping car up an inclined track from the cement shed to the charging platform. The east viaduct is being concreted by cableways which handle buckets from cars through holes left between the ribs of the span in front of the mixing plant. These cars are hauled by cable a short distance to the concrete hopper under the mixer on a narrow-gage track. When not in use the cars are moved out under the bridge and the motor trucks drive right over the track.

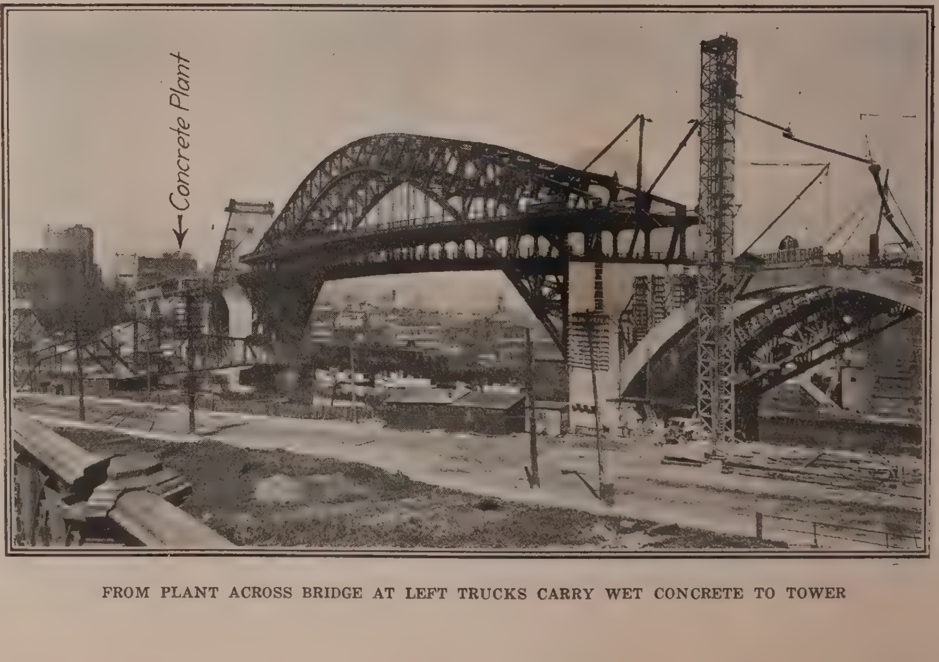
HAULING CONCRETE AT 40 YARDS AN HOUR

The successful hauling of wet concrete to supply a spouting system is made possible by the fact that each of the three 5-ton White trucks employed is able to deliver 2 cu. yd. of mixed concrete every 8 min. This provides a continuous supply for the 1-yd. tower skip, which makes pouring possible at the rate of 40 yd. an hour. The dependability of the system hinges on that of the trucks. Continuous pouring is essential for every unit of the superstructure, and had not the trucks been as reliable as any other type of plant the scheme could never have been worked successfully.

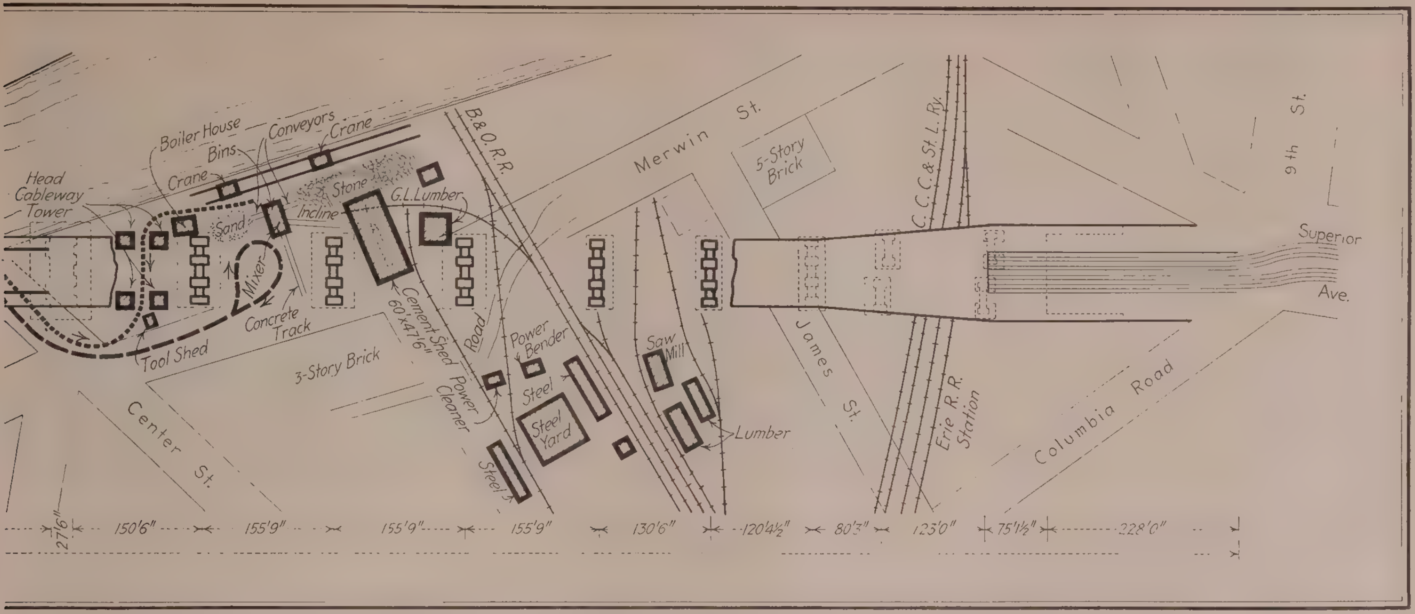
The trucks back up to dump, which takes about 45 sec. Loading from the hopper into which the mixer discharges takes 20 sec., and the round trip of ½ mile can be made in 5 min. The running time does not average this, however, as the swingbridge over which the trucks must pass is frequently opened for short periods, an hour a day being often lost on this account.

Two of the trucks are rented, and valuing the use of these and of the third truck, owned by the contractor, at the prevailing charge of $2.50 an hour, it costs 20 cents per cubic yard to transport the concrete this distance. It would have cost 50 per cent more to haul the material separately, and the contractor has also cut his expense on the job by the cost of providing and operating an additional concrete plant. When the contractor's truck is not hauling concrete it is delivering reinforcing, forms and supplies from the bending tables and storage points to places where work is in progress.

On this one bridge it has been possible for the different contractors to locate their



FROM PLANT ACROSS BRIDGE AT LEFT TRUCKS CARRY WET CONCRETE TO TOWER



BUILT WITH THE HELP OF MOTOR-TRUCK TRANSPORTATION BETWEEN DIFFERENT PARTS OF THE WORK

concrete plants at the point of work and rely on continuous delivery from material yards at the capacity of the plant because of the development of the motor truck. It has also been possible to locate one of these plants with reference to water and rail delivery of materials and rely on its placing concrete in continuous runs a quarter of a mile away and across the river—again because of the development of the motor truck. Although no attempts have been made to break records in its construction, it is difficult to see how this bridge could have been built at the speed attained without trucks. Certainly to have done so would have required a very elaborate plant, complicated by the necessity for keeping in use the river, the streets, the railway tracks and the buildings beneath and adjoining the structure.

The bridge is being completed for Cuyahoga County under the direction of W. A. Stinchcomb, county engineer; A. W. Zesiger, bridge engineer, and K. D. Cowen, engineer of construction. The contractor for the east and west concrete viaducts, on which a great many of the transportation problems have come up, is the Hunkin-Conkey Construction Company, for which Harry Hilton is chief engineer and Harold E. Ketchum is superintendent. The substructure was built by the O'Rourke Engineering Construction Company and the Great Lakes Dredge & Dock Company.

Elephant Butte Reservoir to Serve 233 Years

Service Life Is Estimated by R. R. Coghlan and V. E. Lieb After an Investigation Into the Silt Problem

BASED upon a weight of silt in the dry state experimentally determined at 92.34 lb. per cubic foot, it is estimated that the probable life of the Elephant Butte reservoir is approximately 233 years, determined by the silting probabilities from records by Mr. Follett, according to notes in the *Reclamation Record*. An investigation was undertaken by R. R. Coghlan and V. E. Lieb in March and April, and the average figure, mentioned above, is given in a report by Mr. Coghlan. This investigation to find exact values for the weight of silt in the dry state and to determine the probable sequence in the deposition of such sediment was undertaken because of the very wide variation in the figures used by different investigators.

The silt beds for sampling, selected as typical of average conditions, were bars deposited in the lake during the high water of June and July, 1915, about 15 miles upstream from the dam. The sampling was undertaken in March of this year, when these bars were exposed. Samples were taken at three different locations in the silt beds, the first about 15 ft. from the river and 1 ft. above it, the second about 65 ft. from the river at a slightly higher elevation, both about 1 mile above the delta, and the third about 2 miles above the delta from a bank approximately 20 ft. from the water and 1 ft. above it. Results from seventeen samples are tabulated in Table 1, and the fineness of grain of the samples from the three locations is given in Table 2.

TABLE 1—VALUES FOR SILT SAMPLES

	Maximum	Minimum	Average
Weight per cubic foot, natural state	124.31	96.68	104.75
Percentage moisture	20.89	4.45	11.56
Weight per cubic foot, dry state	101.18	87.90	92.34
Specific gravity	2.657	2.590	2.642
Percentage of voids	46.57	38.97	43.99

A statement forecasting the service life of the Elephant Butte reservoir from the data at hand is questionable at best, but a surmise is possible. The available storage capacity of the reservoir is computed at 2,638,860 acre-feet. Using the records of flow and percentage of silt which passed San Marcial, N. M., from 1897 to 1912 inclusive, computed by Mr. Follett, and the weight of 92.34 lb. for dry silt per cubic foot of deposit, the average annual inflow of silt into the reservoir area during that period was 11,336 acre-feet. Based on this figure, the probable life of the reservoir may be computed as approximately 233 years. This may be influenced by variable and unknown conditions. It might be predicted that with the reservoir silted to half of its capacity and with the delta toe approaching the dam, a succession of dry years in the river above the reservoir would not mean a cessation of water from the reservoir, as the 44 per cent., more or less, of voids in the silt would insure a steady supply of seepage water which would add materially to the flow.

TABLE 2—FINENESS OF SILT

Sieve	Location 1, per cent	Location 2, per cent	Location 3, per cent
Passing No. 200	88.14	79.64	76.56
Passing No. 100	99.78	99.64	99.29

How to Make a Good Impression with a Rubber Stamp

By THOMAS A. HAYDEN

Surveyor General's Office, Phoenix, Ariz.

IN offices where, for filing and other purposes, printed forms are placed on maps, drawings and documents of different kinds by means of rubber stamps, difficulty is frequently experienced in securing a satisfactory impression. In small stamps this difficulty is less marked; but in the larger sizes, uneven printing, or total failure to print at all over the entire area, is the rule rather than the exception.

The noticeably inferior results secured on rough-surfaced paper, such as that in most detail papers, particularly in the better grades, suggested to the writer the obvious expedient of smoothing that portion of the surface on which the impression was to be made. A very little work with a small piece of fine sandpaper taken from an ordinary pencil pointer, such as will be found on any drafting table, resulted in a completely satisfactory surface.

Electric Propulsion for U. S. S. Tennessee

Electric drive for battleships, adopted by the Navy Department after careful investigation, is to be applied in the new U. S. S. Tennessee, a superdreadnought of the largest class, by using two steam turbines of 33,000 hp. driving electric generators which furnish current to four 6700-hp. motors, each motor driving one propeller. The contract for furnishing the electric equipment has been awarded to the Westinghouse Electric & Manufacturing Company of East Pittsburgh, Pa.

Wire Drag Supplements Lead Line in Sounding

Government Surveys of Navigable Waters Made More Trustworthy—Hidden Rocky Pinnacles Easily Discovered

THE inherent danger in the use of the lead-line method alone for the purpose of making soundings and obtaining data from which navigation charts can be prepared is being overcome by the United States Coast and Geodetic Survey by the use of the wire drag. As described in special Bulletin 38 on the elements of chart making, this method is of special value in detecting obstructions and menaces to navigation. The following extracts describe the apparatus and the method of operating the wire drag as used by the Survey:

"Until quite recently the lead-line method was the sole dependence of the chart maker. That it is untrustworthy as applied in many localities is apparent. With the recent greatly increased importance and exacting requirements due to the deeper draft vessels, the opening up of new water areas, the greater demands of our navy, and in general a greater necessity for absolute accuracy owing to frequent marine disasters, its defects became alarming. The most important forms of these menaces, not generally found by the use of the older method, are rocky pinnacles, ledges, boulders, coral reefs, etc. As surveys by the lead-line method failed frequently to reveal even an indication of their presence, it became more and more evident that some new device specially adapted to the needs of such localities was urgently required.

"For this purpose the wire drag was adopted. From its crude original form there has been rapidly developed by the Coast and Geodetic Survey an apparatus which in practice gives absolutely accurate results that are final. It consists of a horizontal bottom wire, supported at intervals by adjustable upright cables suspended from buoys on the surface. These uprights can be lengthened or shortened for various required depths, and to maintain the bottom wire at a given depth below the surface of the water by making allowance for the rise and fall of the tide. The uprights are maintained in a nearly vertical position by means of weights attached to their lower ends. Intermediate between the uprights wooden floats are attached directly to the drag wire to prevent sagging between the uprights. The end weights and buoys are larger than the intermediate, and to them the towing gear from the launches is attached.

OPERATION OF THE WIRE DRAG

"In operation the drag is extended by directing the course of the launch outward from the middle of the drag as well as forward along the center of the area to be swept. In some instances the forward motion of the drag is due entirely to the current, and when this is the case the effort of the launches is expended entirely in maintaining the drag in an extended form. An interesting feature of the apparatus is the signaling system between the end launches, made necessary on account of the great length of the drag, which is sometimes four to five miles.

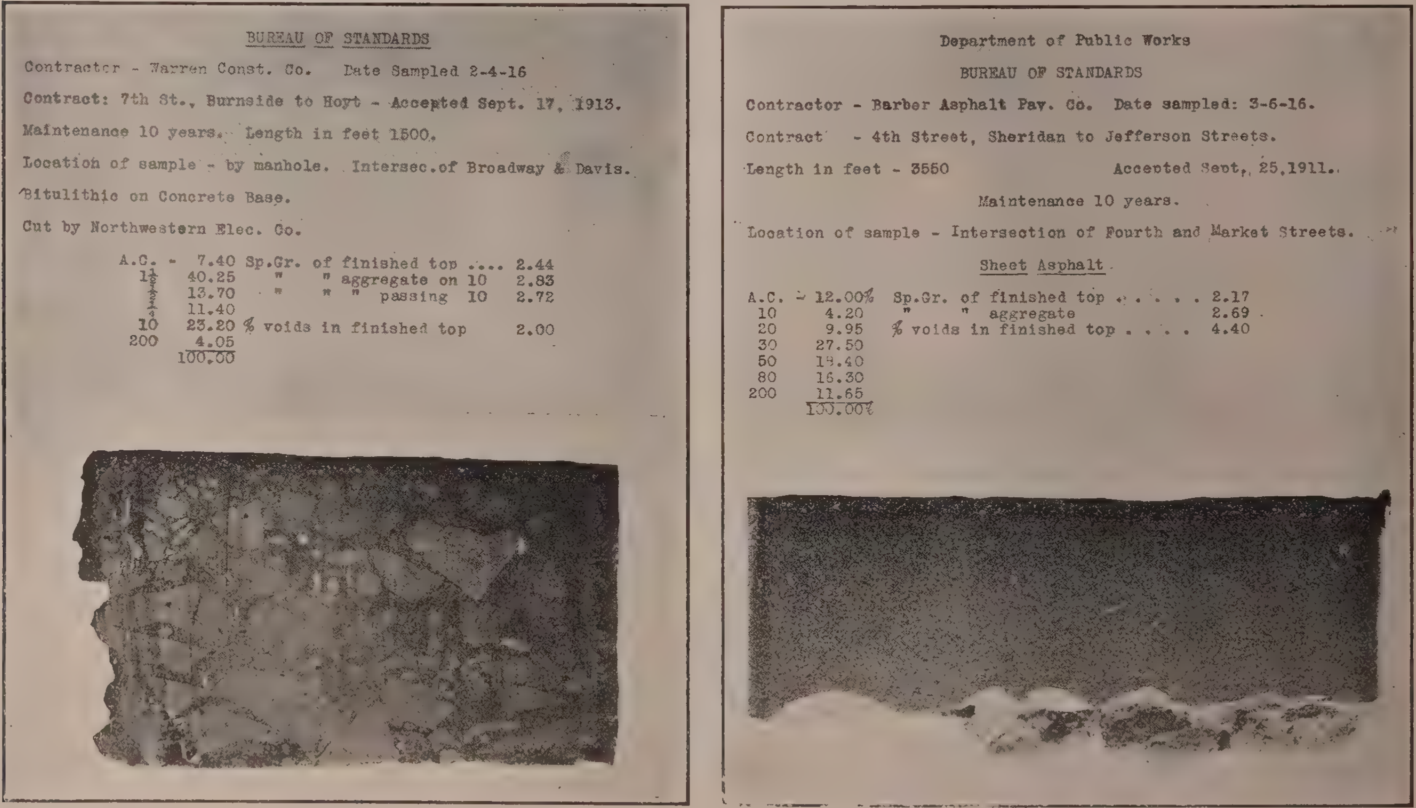
"Upon meeting an obstruction in its course the drag at once indicates the obstruction and points out its location. As soon as the drag wire touches the obstruction there is a marked increase in the tension on the drag, which is noted immediately on the spring balance to which the tow line is attached; and the position of the shoal is shown by the buoys, which line up between the obstruction and the launches. A buoy is then placed at the intersection of the two lines of drag buoys, the drag is cleared and moved ahead on its course, and the detailed examination of the spot is then made by a sounding party in a small tender or sounding boat. The great length of the drag and the maintenance of an ample overlap along adjacent dragged strips insure the completeness of the operation, and the stability of the drag wire at the required depth and its certain indication of any contact with the bottom give ample assurance of the certainty of its results."

Photographs of Samples Aid City Paving Records

Portland Keeps Detailed Statistics of Street Building Materials and Views of Specimen Sections

THE Public Works Department of the city of Portland, Ore., maintains a detailed record of all street paving, giving the proportion and grade of materials used, the date and extent of the work, and other data that might prove useful when there is need of referring to such statistics. The interesting feature of the records, however, is that it has been found feasible, and of great value, to append to each description a photograph of a specimen section of the pavement.

These specimens are secured after the paving is laid, in the case of new work, or are obtained from old pavement when the street is cut for laying mains, etc. The sample is taken to the bureau of standards and is sawed to secure a suitable section by means of a home-made device the cutting edge of which is a wire running in water. The section is cut in a true vertical plane, care being taken that the harder fragments in the aggregate do not cause deflection or breakage. After a suitable specimen section has been secured, the surface is photographed full size and the print is attached to the particular record sheet describing the paving. The accompanying typical samples of records as filed indicate the method used.



BUREAU OF STANDARDS

Contractor - Warren Const. Co. Date Sampled 2-4-16

Contract: 7th St., Burnside to Hoyt - Accepted Sept. 17, 1913.

Maintenance 10 years. Length in feet 1500.

Location of sample - by manhole. Intersec. of Broadway & Davis.

Bitulithic on Concrete Base.

Cut by Northwestern Elec. Co.

```
A.C. -  7.40 Sp.Gr. of finished top .... 2.44
 1½    40.25    "    " aggregate on 10   2.83
  ½    13.70    "    "  "  passing 10    2.72
  ¼    11.40
 10    23.20 % voids in finished top     2.00
200     4.05
      100.00
```

Department of Public Works

BUREAU OF STANDARDS

Contractor - Barber Asphalt Pav. Co. Date sampled: 3-6-16.

Contract - 4th Street, Sheridan to Jefferson Streets.

Length in feet - 3550 Accepted Sept. 25, 1911.

Maintenance 10 years.

Location of sample - Intersection of Fourth and Market Streets.

Sheet Asphalt

```
A.C. - 12.00%  Sp.Gr. of finished top . . . . . 2.17
 10      4.20   "     " aggregate               2.69
 20      9.95  % voids in finished top . . . .  4.40
 30     27.50
 50     18.40
 80     16.30
200     11.65
       100.00%
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TYPICAL SAMPLES OF RECORD SHEETS, WITH PHOTOGRAPHS OF SPECIMEN SECTIONS OF PAVING AS USED BY CITY OF PORTLAND

THE CONSTRUCTION CAMPS WERE SOMEWHAT DIFFERENT FROM THE AMERICAN TYPE

Handling of Filipino Labor One of Problems in Construction of Baguio Railroad

Line to Philippine Summer Capital World's Longest Rack Railroad—Hydraulic Rock Excavation a Feature—Work Suspended Because of European War

By W. M. BUTTS
Assistant Division Engineer, Nashville, Chattanooga & St. Louis Railway, Tullahoma, Tenn.

BAGUIO, the summer capital of the Philippines, was created to provide the islands with a more temperate and invigorating climate than Manila provided during dry seasons. Nestled in a range which rises to more than 9000 ft., the climate incomparable, the mountains covered with pines and oaks and filled with cold springs, the place is a temperate-zone paradise within the tropics. With its cool climate, invigorating atmosphere and wonderful scenery, however, Baguio had one serious drawback—it was hard to reach. After the famous Benguet road was built and washed out repeatedly, such pressure was put upon the Manila Railroad Company that it was obliged to undertake the building of an extension to Baguio.

In 1910 a party headed by C. J. Hogue was selected to go to the island and make surveys for the proposed line. The route chosen by the government through the Budd River Cañon (that followed by the Benguet road) was rejected upon reconnaissance, and all preliminary lines were run from Aringay on the Gulf of Lingeayen, to which point the railroad already reached.

ADHESION OR RACK LINE

The condition suggested a comparison of an adhesion and a rack line. The former, with a 4-per cent grade, would have required a length, it was found, of 53 miles, and the cost would have been prodigious. The second preliminary, for a rack line, was surveyed with a maximum gradient of 12 per cent and a maximum curvature of 15 deg. 16 min. This line figured 25 miles in length, with a lower cost per mile. It was therefore selected for the route.

TABLE 1—ESTIMATED QUANTITIES AND PRICES

Right-of-way, 385 acres, at	$65.00
Clearing and grubbing, 286 acres, at	30.00
Earthwork, 650,760 cu. m., at	.30
Loose rock, 345,100 cu. m., at	.45
Solid rock, 459,960 cu. m., at	.70
Concrete, 84,650 cu. m., at	5.00
Riprap, 25,660 cu. m., at	2.60
Bridge steel, 4,005,200 lb., at	.06
Tunnels, 970 lin. m., at	300.00
Timber for false work, 662,000 ft. c.m., at	50.00
Piling, 39,130 lin. ft., at	.40

Table 1, the estimate made on a projected location, will give a slight idea of the difficulties foreseen in the construction of this 25-mile extension. Subsequent changes in the alignment increased the amount of right-of-way, but as most of the changes were upon government land, which was deeded gratis, no material increase was effected thereby. The amount provided for clearing was far too small, as the dense tropical growth on the lower parts of the line soon proved. The estimates of earthwork were too small because of the tendency to slide, the astonishingly small amount of rock and the desire on the part of the engineers to get into the hill because of the heavy rainfall. The cost of nearly all concrete deposited was about $15 per cubic meter. The final estimate for steel was 7,148,000 lb. By subsequent changes in alignment the tunnel distance was nearly doubled.

The government being anxious to see the railroad in operation at the very earliest date possible, work was started January, 1912. The extension was divided into two parts. Mr. Castilvi was to push up from the lowlands and Mr. Hogue was to work from Baguio down. The difficulties met and solutions presented on the upper division were more novel.

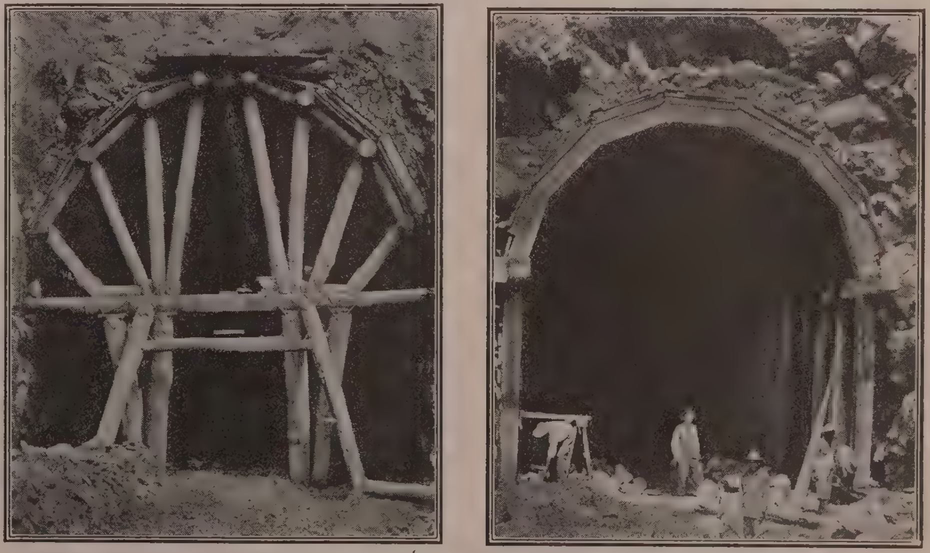
The labor in the upper division was, in most cases, supplied by the government. Igorrotes from the northern province were ordered to report at Baguio for work in stages of three months. They were willing workers, but though quick to learn were not accustomed to disciplined labor. The wages were 12½ to 20 cents a day for boys, 25 cents for men and 50 cents for "little bosses." The laborers were furnished rations, which consisted of a can of salmon to four men and about a quart of rice per man each day. Sometimes "Igorrote turkeys" (dogs), pigs and tobacco were issued as specials.

The cost per man on the job, inclusive of native superintendents, cooks and rations, averaged about 35 cents per man. These wages were considered extravagantly high for the Orient. The old maxim, however, that labor is worth only what it costs, proved true. The men were unaccustomed to pick-and-shovel work. It was more or less compulsory, and although at first it possessed a novelty, this soon wore off as the monotony told on the spirits of these wild, free people of the mountains. They grew homesick and slipped away; and as soon as the rain came, nearly all of them went home to till their rice paddies.

SMALL CONTRACTS BEST

This type of labor, although the government continued to furnish it, proved less efficient than labor obtained by other means. A system of contracting with the individual *bucknans* of small groups proved more valuable. By this means a head man was advanced tools, provisions and occasionally dynamite, which were later deducted from his estimate. He was paid 17½ cents per cubic meter for earth, 35 cents for loose rock and 50 cents for solid rock for ordinary excavation or embankment. A careful account was kept on the contractor to ascertain his earnings, and occasionally these rates were increased to make the job attractive to the Igorrotes.

Japanese carpenters on the work were paid from $1.50 to $1.75; Filipino carpenters, 65 cents; Filipino bosses and miners used in tunnels, $1 to $1.50; Filipino time keepers and clerks, 35 to 50 cents. All



THE EUROPEAN AND THE AMERICAN METHODS OF TIMBERING TUNNELS COMPARED

IGORROTES AND THEIR WIVES WORKED TOGETHER ON THE GRADING

NATIVES WERE EMPLOYED AS RODMEN AND INSTRUMENT BEARERS

received rations. The salaries of the white force, with occasional raises, varied by experience and length of service, were as shown in Table 2. The assistant to the president of the railroad received $500 a month and the president $23,500 a year.

Table 2—Engineering Salaries on Work

Engineer in charge		$268
Resident engineer	$200 to	225
Assistant engineer	150 to	165
Instrument man and draftsman		150
Rodman and draftsman	$90 to	125
Foreman on hydraulic work		125
General foreman (government forces)		150
Ordinary white foreman		75

One of the features most forcibly impressed on the engineer in going over the line is the extraordinary provision for drainage. Baguio made what is thought to be a world's record in June, 1911. In a single day 43 in. of rain fell, and 30 in. fell in three hours, according to the weather bureau report. Nearly 7 per cent of the entire railroad is bridge.

Rock Excavated by Water

Another noteworthy feature is the hydraulic plant erected to cheapen the excavation. A head ranging from 150 to 300 ft. was used, with the old California mining application of flume, penstock, pressure pipe and monitor. The plant pays for itself in the first two months of operation. The cost of excavation by this method was between two and three cents per cubic meter, covering several months of operation; and because the amount of material was so great the expense, including depreciation, was very little more. Clay, shale and some very hard rock were encountered. Explosives were used on the harder materials, the pieces being carried out of the cuts in flumes.

The tunnels—of which there are six, the longest being half a mile long—presented some interesting situations. All of them were driven by hand drilling, and usually with the ventilation provided by home-made hand-driven turbines, which drew the foul air and the gases from the heading through tin pipes. Because of the difficulty of transporting machinery—everything being brought in on the backs of men—these primitive methods were necessary if the work was to be rushed.

The railroad brought a party of Italian and Swiss tunnel men fresh from work in the Alps to the island to handle this work, but their cumbersome methods, their failure to adapt themselves to the conditions and their great fund of tenderfoot tendencies caused endless trouble. The style of timbering used by them is shown, as is the American type finally adopted. The former was characterized by difficulties in erection, lack of working room and insecurity; the latter embodied ease of erection and removal, closeness to the bore of the tunnel, strength and plenty of working room.

Tunnels Lined With Concrete

All tunnels were lined with concrete. Timbering for some of them was made from nearby trees, but on the longer tunnel a sufficient quantity was needed to justify the construction of a cableway several miles long, with one span more than a mile in length to a sawmill nearly a mile higher than the site of the tunnel.

The European War necessitated cutting down the work, but its completion, which will require two years, is assured. When the road is finished it will be the longest rack line in the world; one of the most crooked of lines, 55 per cent of its length being curves, and probably one of the most expensive for its length, as the cost will probably reach $5,000,000. When completed, however, it will be a monument to American perseverance and, regardless of cost, will be a paying investment, as the returns will be measured in renewed health and vigor reaped by those who journey to Baguio each year.

EVEN ROCK WAS EXCAVATED BY WATER JETS

Making Specifications Handy for the Contractor

Portland, Oregon, Issues Loose-Leaf Forms Covering Materials and Methods for City Work

THE city of Portland, Ore., has adopted a convenient form for publishing specifications which is intended to make it easy for the contractor to keep handy reference files and at the same time to reduce the cost to the city and simplify the getting out of plans and specifications for new work.

About fifty-five sets of standard specifications have been prepared, covering materials and methods of all sorts from vitrified paving blocks to general requirements for bridges and viaducts. Each set is printed on uniform 4½ x 7½ in. sheets perforated for loose-leaf binding, and is numbered for entry on an index supplied with the sets. As new work makes it necessary to prepare specifications not already adopted as standard, these are completed once for all and issued as additions to the loose-leaf set.

With this plan in effect contractors are encouraged to provide a small binder in which the sets can be kept, and thus embody in a single book of handy pocket size all city standards. From the standpoint of the city's engineering department, getting out specifications for new work of ordinary character requires only actual plans for the construction involved and references by number to the standards which are to apply particularly.

The plan has been developed by Philip H. Dater, city engineer of Portland.

Credit Given for Calcium Chloride Tests

Through an oversight the name of H. A. Davis, assistant engineer-physicist of the U. S. Bureau of Standards, who carried out all the detail work in connection with the tests, was not mentioned in the article on the effect of calcium chloride on the rate of increase in strength of concrete, on page 266 of the issue of Aug. 26. Mr. Wig requests that the fullest credit be given to Mr. Davis for this work.

Steel Arches Are Designed to Eliminate Rim Tension in Oil Reservoirs

New Design Involves Use of Concrete Abutments Carrying Suspended Parabolic Arches Made of Thin Steel Plates

By HENRY B. POST
Palo Alto, Cal.

THE RAPID GROWTH of the oil industry and the tremendous increase in production of crude oil in recent years have presented to the engineer new problems in finding efficient and economical facilities for storing oil in large quantities.

The first large storage units were uncovered earthen sumps, built by excavating and piling the earth as levees around the rim. These proved unsatisfactory because of leakage and evaporation losses, and later designs provided a concrete lining and wooden roof to check these losses, the lining being a 3-in. concrete slab reinforced with a wire mesh, and the roof supported on wooden columns and rafters and covered with tar and gravel. A few structural containers were also built, such as the 1,000,000-bbl. reinforced-concrete reservoir erected by the Union Oil Company at San Luis Obispo in 1906, a partial failure of which occurred four years later.

LINED SUMPS NOT SATISFACTORY

The excavated, lined sump represents an investment which offers no salvage or a possibility of removing to another locality in case of a failure in the oil supply; and with the best of care in its construction, leakage results from settlement cracks in the concrete lining and bottom, and there is always the danger of blowing out the thin shell on account of a chance gopher hole or because of an inadequate backfill, or leaks may develop which will never be found until the sump is drained.

For these reasons steel tankage is being adopted by practically all California oil companies. The tanks reach the limit of economy at about 55,000 bbl., the cost being prohibitive for larger capacities because of the heavy plate required and the excessive fabrication costs. The larger the container, the lower of course the cost per barrel. In the cylindrical steel tank the thickness of the containing wall is a function of the depth of the oil and the diameter of the container. The larger the diameter, the greater the rim tension, hence the greater the thickness of resulting plate necessary to resist that tension.

THE NEW DESIGN

To meet the demands for steel tankage in large units which would be efficient as well as economical, a design involving the suspended steel arch has been worked out for the Dutch Shell Company. Plans and specifications have been prepared for a 100,000-bbl. reservoir of this design, and the type has been accepted by the company as the most economical yet proposed for future storage extensions. In the new design the reservoir comprises a series of steel arches supported on concrete buttresses, the arches being placed so as to receive the load in tension and transmit it as compression to the buttresses, which in turn carry it to the ground.

Each arch is a section of the surface of the frustrum of an inverted cone, which assumes a parabolic cross-section, normal to the axis of the cone when the load is applied. The buttresses are of reinforced concrete and are placed on radial lines from the center of the container, and on the circumference of a circle, thus giving the tank a circular perimeter. Each buttress has a rounded nose on its upper edge which gives ample clearance in riveting together the nose and arch plate of the arch on each side of the buttress. The inclination of the oil face of the buttress is 45 deg. with the horizontal, so that the span of arch increases from the floor line upward.

The true curve for a linear arch sustaining a uniform load is a parabola whose maximum tension exists at the point of suspension. The suspended steel arch used in this design has a parabolic cross-section, as the load being hydrostatic is uniform across any horizontal plane at a given depth.

ANALYSIS OF DESIGN

Assuming the formula for the maximum tension in a parabolic linear arch as

$$T = \frac{w}{8h}\sqrt{L^4 + 16h^2L^2} \qquad (1)$$

in which T = maximum tension at point of support; h, rise of arch at crown line; L, span of arch in feet at given depth d (16 ft. at floor line); w, intensity of pressure at given depth d; t, thickness of plate required, in inches (assumed at 0.25 in.); S, safe working stress of steel (assumed at 12,000 lb. per square inch), and e, efficiency of riveted joint (75 per cent), assuming d as 30 ft. Then

$$T = 0.75 \times 12{,}000 \times 0.25 = 2250 \text{ lb.}$$

$w = 30 \times 62.5 = 1875$ lb. per square foot, and substituting in equation (1) we have

$$2250 = \frac{1875}{8h}\sqrt{16^4 + 16^3h^2}$$

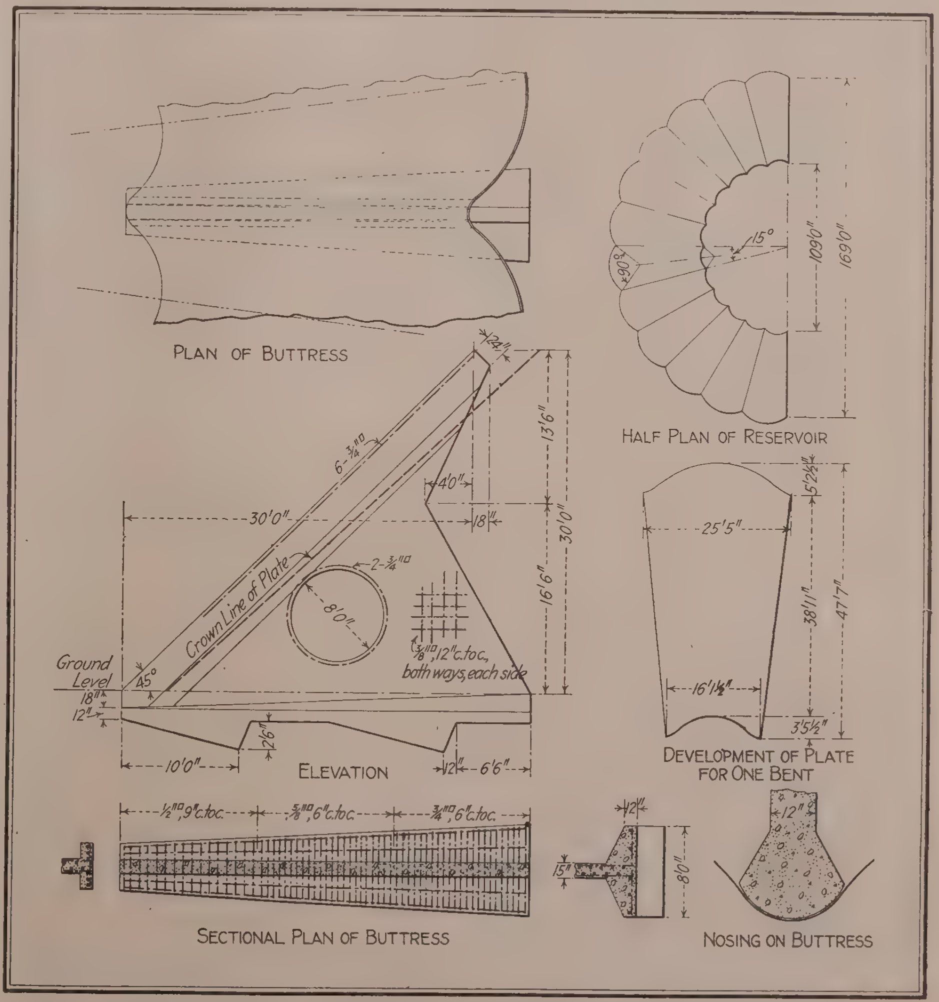
and

$$h = 0.1039\sqrt{16^4 + 16^3h^2} = 4.05 \text{ ft.}$$

The half span $(L/2) = 8.00$ ft., so that substituting these values in the formula $y = hx^2 \div (L/2)^2$ it is possible to figure the x and y abscissas and ordinates to determine the true curvature of the arch. The rise and span increases proportionately up the arch to the top, due to the slope of the arch face and the fact that the buttresses radiate from the center of the tank.

PLATE THICKNESS CONSTANT

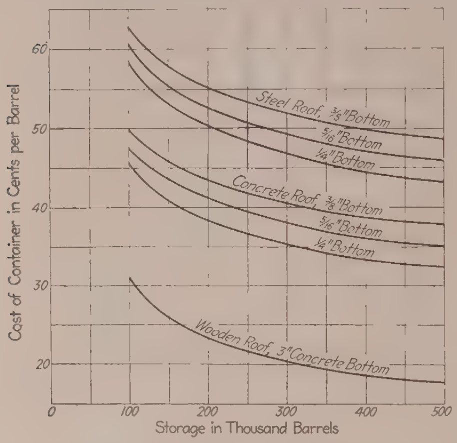
In the foregoing calculations, t, the thickness of the arch plate, was assumed to be ¼ in., because that is as thin as it could practically be taken. This thickness remains constant and is independent of the diameter of tank under a constant depth of oil, being only a function of the depth and the curvature and span of the individual arch. As each arch is symmetrical with respect to its supporting buttress, there is no condition of unbalanced loading and no component of pressure exists to cause rim tension. These facts are notable as compared to the cylindrical steel



DETAILS OF CONCRETE BUTTRESSES AND STEEL PLATES FOR TYPICAL DESIGN tank, in which the thickness of containing wall varies directly with the diameter of the container.

The buttress is designed to be safe against overturning and sliding, the resultant dead load of 780,000 lb. cutting the footing at the middle of the center third. The stepped footing, as indicated on the accompanying drawing, gives an added factor of safety against sliding. The average base loading is 1.85 tons per square foot, which can be increased or decreased as the bearing power of the sub-base will permit.

Temperature stresses are absorbed in the steel arch, which expands or contracts with a rise and fall in temperature, while the buttress is reinforced with steel to take care of temperature changes. The floor may be constructed of riveted steel plate of desired thickness, or a concrete floor can be used. In both instances an expansion joint must be provided for at the junction of floor and wall.



COST DATA FOR NEW RESERVOIRS

The question of evaporation and the importance attached to it by oil companies determine the preferable type of roof. A gas-tight steel roof is best, but expensive at the present market price of steel. The wooden roof, as now used on large reservoirs, is not gas-tight and is a fire menace. A concrete roof, supported on structural steel columns and rafters, would because of its low coefficient of conductivity cut down the evaporation losses to a minimum, would be within the limits of economy and would have the added feature of being fireproof.

APPROXIMATE COST

The series of curves, as shown in the accompanying diagram, give the approximate cost of the suspended steel arch construction for various thicknesses of steel bottom and steel or concrete roof. The wide range of thickness of steel for use in the reservoir bottom is given where salt water is present in the oil. The desirable thickness may be as much as ⅜ in. in a structure where a ¼-in. plate would otherwise suffice. The lowest curve is based on the steel wall and concrete buttress design, with concrete floor reinforced with Clinton wire mesh, and has a wooden roof covered with tar and gravel. At the present market price of steel, steel tankage in 55,000-bbl. units costs approximately 55 cents per barrel storage capacity. In the suspended arch system, with gas-tight steel roof and ¼-in. steel floor, the cost at 125,000 bbl. is likewise 55 cents, while for larger units a considerable saving is effected. If a concrete roof is used the cost per barrel is 42½ cents, decreasing to 32 cents at a 500,000-bbl. capacity tank. To these costs a salvage value on the steel at the expiration of the life of the structure may be applied, thus reducing the first cost considerably.

The advantages of a structural container of this type over the excavated, concrete-lined sump are that in the former the storage is all above the ground, where a leak may be readily detected and calked; the units are all standard, so that rapid erection is possible, while the tank may at any time be dismantled and the steel used again at a new location.

This system of construction makes it possible to store oil in large steel units and reduces the cost for two reasons—first, because of the economical use of steel in the wall construction; and, second, because of the large capacities of units feasible with this type of structure. The design has been developed and patent applied for by the writer.

16-Foot Rock Road in Africa Costs $5,500 per Mile

Inefficient Labor, Scarcity of Material and Absence of Machinery Add to Natural Difficulties of Construction

ROAD BUILDING in British East Africa was not seriously attempted until 1905, when it was decided to construct roads to feed the Uganda Railway. One of the first highways to be rebuilt was that between Fort Hall, the administration center of the Kenia Province, and Nairobi, situated in the highlands 5500 ft. above sea level and now the capital. These cities had been connected by a mere trail about 80 miles long, full of bad grades and dangerous river crossings. The reconnaissance was made, the route selected and work started from Nairobi. Native laborers were employed, and the first work was the giving of instruction in the use of pick and shovel. The details of the construction, as presented in a recently issued *Proceedings* of the Institute of Civil Engineers, follow:

The expected traffic did not warrant any great expenditure, nor were funds available at that time. It was therefore decided to form the surface of a material known locally as "murrum." This substance, which is found in large deposits widely distributed throughout the protectorate, is a kind of iron-stone, composed of about 30 per cent free iron, 4 per cent manganese, oxides of both these substances, and a quantity of earthy matter. It is fairly hard and when beaten or rolled with water forms a hard, brick-like surface.

The roadbed having been graded to the required section, a soling of murrum blocks about 1 ft. deep was laid. The interstices were filled with smaller pieces and the surface finally formed by ramming.

SWAMPS TOO DEEP FOR PILES

Several large flowing papyrus swamps were encountered, which were unavoidable without unduly lengthening the route. These upon careful survey were found to be too deep and loose for pile work, and hence the following method was adopted: The papyrus roots were cut out by natives for a width of about 100 yd. to allow of free surface flow and to determine the positions of the necessary bridges. On the bed of mud thus cleared fascines about 18 in. in diameter and 18 to 20 ft. long, composed of green papyrus stalks tightly bound with strips of papyrus, were laid first longitudinally and then, in a second layer, transversely. Each fascine and each layer was carefully and strongly bound to its neighbor with papyrus strips, each layer forming a compact raft.

When several layers had been placed, earth and stone were deposited on top, causing the whole mass to sink gradually. The sinkage was such that a horse could be driven across the causeway at the end of a day's work, yet there would be no trace of the structure the following morning. After this procedure had been carried out several times and sinkage was seen to be much slower, culvert pipes were built into and through the mass at various points and foundations of rough stone were prepared for two temporary bridges. Finally sinkage ceased and the bridges were put in, the roadway being permanently made and raised about 5 ft. above the water level.

TRAPROCK USED

A kind of traprock was discovered within workable distance of Nairobi. It was of bluish-black color, with a specific gravity of 3, practically nonabsorbent, and exceedingly tough and hard. As it was impossible to consolidate that material sufficiently with the 2 to 4 ton ox-drawn rollers which had been used until then, a number of 10-ton steam rollers were imported to deal with it.

The method employed after the new equipment was procured was to strip the black cotton soil for about 10 in. and to steam-roll this bed to the requisite semi-elliptical section, with the crown 5 in. higher than the sides on a 16-ft. road. Upon this bed a 9-in. layer of quarry chips of the softer stone, broken to about 6 to 8 in. gage, was spread and dry-rolled until it was thoroughly compact and true to section. A 4-in. layer of trap ballast, broken to 2½-in. gage, was then spread and dry-rolled until firm. It was then well watered and again rolled wet, a binding of murrum being used as a top dressing.

ROADS WEAR WELL

These roads wear well and are said to be quite equal to most English roads of a few years ago. The cost of a 16-ft. road was about $2,000 per mile. Later experiments have shown that the 2½-in. gage ballast was too large, and that consequently it picked up badly after considerable wear. It is now found that the best gage for ballast is 2 in., with about 20 per cent of 1½-in. gage mixed with it.

The latest first-class roads are made with soling as before, but hand-packed on edge, and with a 6-in. thickness of ballast laid in two 3-in. layers and consolidated separately. The surface is tar-grouted when perfectly dry and ¼ to ½ in. screenings from the broken ballast are spread as filling and lightly rolled. The surface is finished with a sprinkling of sand. The cost of labor and materials having recently increased, a 16-ft. road as last described now costs $5,500 per mile.

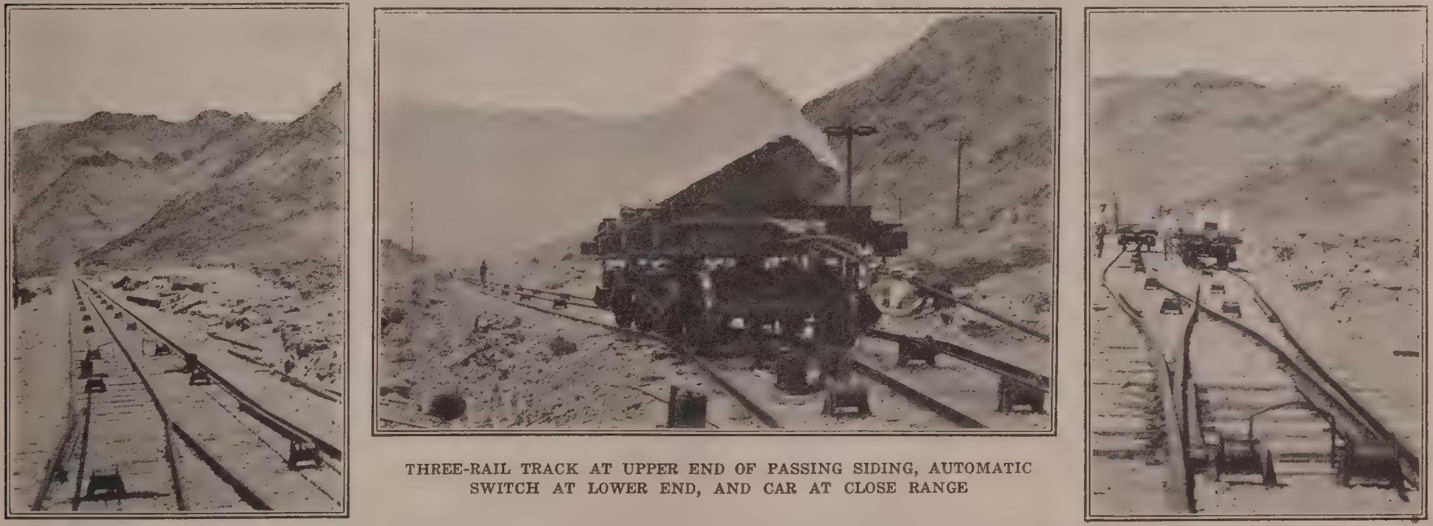
It has been found that excellent light carriage roads and pavements in the province can be so made. The method of construction is practically similar to that for murrum roads, except that a coating of tar is laid when the surface is thoroughly dry, the tar being finally sprinkled with sand. The cost of construction of such a pavement or carriageway is approximately $1,100 per mile for a 16-ft. width.

Cableway Railroad Affords Access to Nevada Quarry

Effects Straight-Line Ascent of 1266 Feet in 3 Miles at Plant of American Carrara Marble Company

A STRAIGHT-LINE incline cable railroad 15,945 ft. long effects an ascent of 1266 ft. from the town of Carrara, in southwestern Nevada, to the quarry of the American Carrara Marble Company, on the slope of the mountains. The trackage consists of a two-rail track from the foot of the incline to a passing siding midway between the terminal and a three-rail track from the siding to the upper end. Two cars, connected by a single wire rope 16,000 ft. long, operate on the track, the arrangement being such that the cars always meet at the passing siding and pass each other without requiring the usual throwing of switches.

The quarries are located about three miles up the mountains from Carrara. The company's offices and the dwellings for the employees are all located in Carrara, and the problems of bringing the marble from the quarry to the railroad and carrying the employees to and from the quarry made it necessary to resort to something other than straight adhesion ascent. The cost of switchbacks, it was found, would have been prohibitive, and their operation would not, it was thought, be nearly as satisfactory as the straight-line incline.


THREE-RAIL TRACK AT UPPER END OF PASSING SIDING, AUTOMATIC SWITCH AT LOWER END, AND CAR AT CLOSE RANGE

With the railway as installed the total length of car travel between terminals is 14,780 ft. The average grade of the line is 8.54 per cent, the maximum grade at the top being 13½ per cent and the grade at the bottom 2.13 per cent. The track gage is 40 in. The rails are 56 lb.

AUTOMATIC SWITCH AT PASSING SIDING

At the lower end of the turnout, which is approximately 150 ft. long, is an automatic point switch. Supposing that the descending car is on the left-hand track, as it trails through this switch the flanges of its wheels throw the switch to the left-hand track. Returning up the incline, this car reaches the switch first and takes its proper track, and immediately afterward the other car, descending, throws the switch to its track. Thus without the need of any switchman each car takes its proper track. The switch points are counterweighted so that they will remain firmly in position until thrown by the descending car.

Three rails instead of two are used above the siding to avoid complications in the disposition of the cable. Because one car would always be below the upper switch when the other was passing over it, it would be impossible to have the cable for the lower car pass over the switch rail, and it would therefore be necessary to cut each rail between frog and switch point to pass the cable through. With the three-rail arrangement each cable is on its own track and there is no cutting of rails required. At the lower switch it is possible to pass the cable over the rail, for the reason that each car gets down and back before the other reaches the switch.

At the upper terminal there are three-rail switches which obviate the necessity of having the car cross from one side to the other while being brought to the upper terminal.

CARS AND THEIR OPERATION.

The cars are of structural steel, with platforms 16 ft. long and 5 ft. wide, and are mounted on four-wheel swiveling trucks with 24-in. wheels. They are fitted with handbrakes, which are used, however, only when the cars are in the quarry or at the finishing plant at the foot of the incline. Each is designed for a load of 50,000 lb. They were designed and built by the Union Iron Works, Hoboken, N. J.

The cars are operated by a single wire rope 16,000 ft. long, 1 in. in diameter, manufactured by the A. Leschen & Sons Rope Company, St. Louis, running on 750 Lidgerwood rope rollers, especially designed and self-lubricating. The hoist, built by the Lidgerwood Manufacturing Company, is designed to lower a loaded car with an empty car ascending or to hoist a maximum load of three tons with an empty car descending at a uniform rope speed of 700 ft. per minute, operated by a three-phase 60-cycle 440-volt alternating-current motor. When a loaded car is descending the motor automatically becomes a generator and returns current to the line, this providing automatic breaking and a uniform car speed.

The hoist is of the double-drum endless rope type, the drums fitted with slip rings. The drums are arranged tandem, with the rear drum bolted to the drum gear and the front drum so arranged as to serve for an idler. Each is 53 in. in diameter. There is a magnetic automatic brake to hold cars in case of current failure, also an overwinding device to bring the cars to rest at the terminals. For emergency purposes only a heavy hand-operated post brake is fitted on the rear drum. The hoist is operated by a 100-hp. General Electric slip-ring induction motor.

The upper terminal is higher than the quarry. The difference in elevation of the upper terminal and the quarry floor is such that the empty cars descend to the quarry by gravity, while the loaded cars are brought out by means of a Lidgerwood single-friction-drum electric hoist.

At the lower terminal the loaded cars are taken to the finishing plant by means of a storage-battery locomotive.

Effect of Vibration in Factory Buildings

Preliminary Report of Investigation Shows Wide Diversity of Opinion and Experience —Exact Data Not Available

WHILE the final comprehensive report of the results of a study of the effects of vibration in structures upon the operation of machines and the efficiency of labor, undertaken by the Aberthaw Construction Company of Boston, by means of a questionnaire sent to professional men and manufacturers, is not yet completed, a preliminary report recently issued indicates the need for further exact information, which is solicited. The replies to three definite questions present a wide diversity of experience and opinion, yet only about one-third of them can be classed as informative. The following brief abstracts from the preliminary report are of special interest to designing engineers:

EFFECT OF FREQUENCY OF VIBRATION

The effect of coincidence between the natural frequency of vibration of a floor and that of a source of disturbance is well illustrated by the following experience in connection with the testing of a small engine upon a floor of timber construction: At a speed of about 550 r.p.m. the intensity of the floor vibration was so great that it was impossible to work in the drafting room located on the same floor more than 100 ft. away; but this effect entirely disappeared when the speed was either increased or decreased by about 50 r.p.m. When the disturbing force is represented by a number of machines at practically the same speed, the effect may be like that of dancers upon a floor or soldiers marching over a bridge, and prove most destructive to the entire structure if the step time coincides with its natural pitch.

Obviously, most vibrations are the result of several components, and records must be made of not only the vertical but also the horizontal components, both longitudinally and crosswise of the building. Vibration recorders are modeled on the principle of the seismograph; the three-component type developed by Maurice Deutsch of New York and Prof. Elmer E. Hall of the University of California is much lighter than the ordinary seismograph, thus rendering it capable of recording vibrations of higher frequency. The records are made on a rotating drum covered with smoked paper by a recorder which separates a given vibration into three components, two horizontal components at right angles to each other and the vertical component. These three components are recorded simultaneously.

Obviously, the type of construction and the extent to which it permits or prevents vibration must be considered. The context of many of the quotations which have been selected referred to buildings, usually old, entirely unsuited to the requirements. Hence the resulting vibrations. Other correspondence shows with equal clearness that the absence of vibrations is due to the rigidity of the structure, to foresight in the placing of certain machines on solid foundations, to the proper cushioning of others and such arrangements of duplicate machines operating at the same speed as to avoid cumulative effects.

The general experience is that severe vibration tends to tire the workmen and make them nervous, with the result that they become irritable and inefficient. The plant manager of a large concern says that he has had four different clerks leave because they could not stand the vibration of the building. During the past nine years, about eight or ten men left because they found they could not do a day's work on the chipping hammer floor because of vibrations.

Machine Output Reduced

An instructive contrast in conditions and results is shown in a letter from a consulting engineer. A mill in which weaving apparatus was originally located was of the old-fashioned mill type, but rather light, and the looms could not run more than 120 picks per minute without serious difficulty with breaking threads. In the new plant the design speed was about 145, but through error it was made 160. When the plant was started, in spite of the superintendent's vigorous complaints, no trouble was experienced, and the mill is at present running at this speed with less loss, so far as breakage is concerned, than was experienced in the old mill at far slower speed, and of course with greatly increased output. It is claimed that this was owing solely to lack of vibration.

Solid foundations apparently insure greater output. A case is cited of one machine which was first placed directly on the floor and vibrated very badly. To overcome this vibration, the floor was cut away around the machine and a foundation put under it. The increased output is claimed to be almost 40 per cent, due to the fact that the operator can take measurements with the machine running when there is no vibration, but was unable to do so where the vibration was so great. Apparently, the quality of the work is also considerably improved. An engineer says that perhaps one of the reasons why some of the English and other foreign fabrics are better than American fabrics is that greater attention has been given to the construction of their mill floors, which are surprisingly free from disturbing vibrations.

The general effect of vibrations in machine shops is clearly expressed by the following quotation: "With the heavier tools where there is an excessive amount of vibration, the depth of the cut is limited, and we cannot use the full power of the tool. It produces a sort of chattering which marks the work and limits the amount of stock which can be removed in one cut." An industrial engineer states that there is one point where the vibration of buildings is not considered sufficiently, and that is in transmission of power by shafting. The losses caused by vibration in such transmissions are considerable.

Design to Decrease Vibration

The trouble caused by reciprocating machinery may be eliminated by proper cushioning or bracing. Where machinery creates more or less vibration due to shock, an effort should be made to use either a massive construction to absorb the shock or else put in direct supports which will transmit the vibration to a point below the foundation. Statements regarding the comparative merits of different types of construction cover a wide range of experience and opinion. In the case of a knitting mill in which considerable trouble with combination steam and joist construction buildings was experienced, it was found that buildings of modern reinforced concrete having heavy machines on the first and second floors showed no sagging, nor is any vibration noticeable.

The replies include a great number of statements from consulting and designing engineers, ranging from the opinion that there are no material advantages in a reinforced-concrete building to the following: "The owners had some mill construction buildings in use before we built the reinforced-concrete buildings. Some sections of the former vibrated like drums, but we believe the concrete construction has proven quite free from vibration."

Fifty-Mile Road in Utah Costs $26,000

Built on Ground So Level That Grading Was Unnecessary—Construction at Rate of a Mile a Day

A FIFTY-MILE ROAD has been almost completed in Utah across the Great Salt Lake desert, the estimated cost of which is $26,000. The Wendover road, as the highway is known, is built on a straight line, and throughout the entire length the grade is practically the same. In fact, it is said that a spirit level laid down at any point will show no indication of a grade. The route connects Knolls, on the east side of the desert, with Salduro, on the west edge.

As the route was to parallel the track of the Western Pacific Railroad, the survey consisted of driving stakes 110 ft. from the center of the railroad to the center of the new highway. A 70-hp. tractor of the track-laying type was used in carrying on the work at the rate of a mile a day. A 4-in. crown was formed and side slopes built with a ratio of 1½:1. In the spring a 6-in. layer of gravel will be added.

About twenty-five miles of the road required no work of any kind, as it was high enough to have a natural drainage, and was smooth and level as well. This reduced the necessary expenditure to $11,000 for the work already completed. The additional cost for surfacing to be done next year is estimated at $15,000. The new route reduces the length of the Lincoln highway by nearly 100 miles.

ROAD WAS BUILT ON FLAT SALT BEDS

GRAVEL SURFACING WILL BE DONE IN SPRING

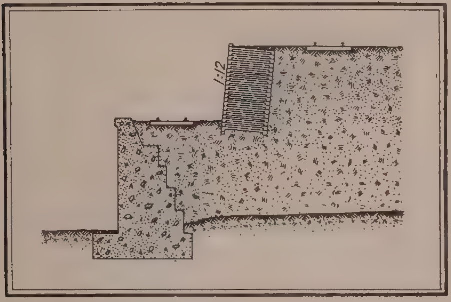
New York State Issues Unique Highway Map

A complete highway map which folds into a size that can be conveniently carried in a pocket and shows not only the condition of the various roads but also points of historical interest has recently been issued by the New York State Commission of Highways. The map is printed in black on thin, tough white paper. The condition of the roads is indicated by symbols. Historical references are printed on the back in alphabetical order. By means of key numbers printed on the map the user can quickly locate the point desired and determine the route to follow.

Rock Island Finds Concrete Cribbing Effective

Gets Satisfactory Results from Its Use in Place of Retaining Walls at Certain Locations of Chicago Track Elevation

VARIOUS elements entering into the question as to the advisability of the use of concrete cribbing in place of retaining walls in special cases have been under close observation by the Chicago, Rock Island & Pacific Railway on its track elevation at Chicago. Thus far the results as to cost, efficiency and appearance are very favorable to the cribbing. The economy in the use of this type of structure is brought out most prominently on two-level fills where a retaining wall between tracks would have to be carried down through many feet of fill to the solid foundation.

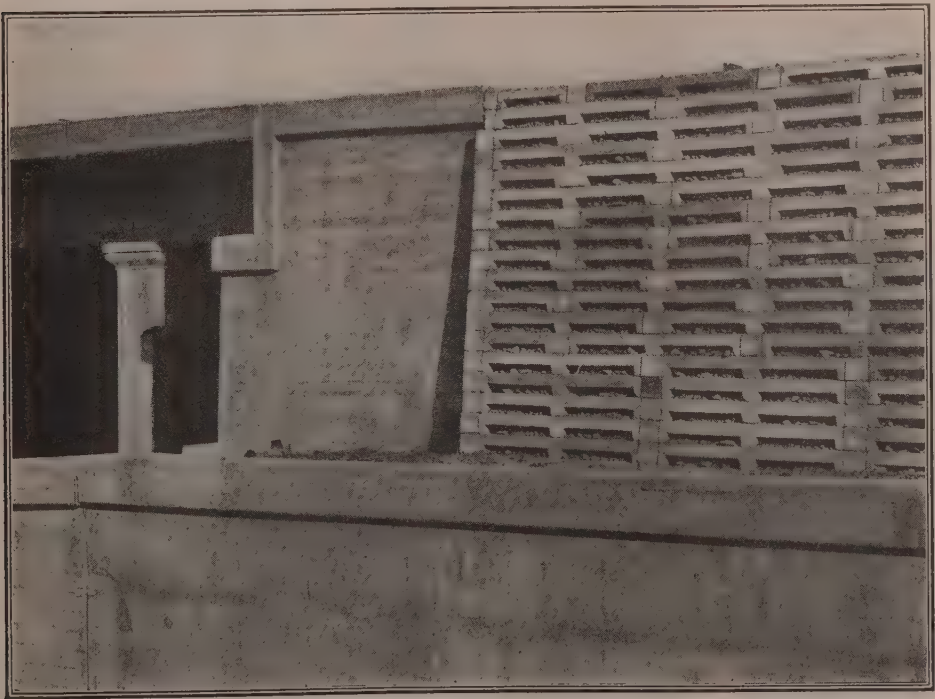


MARKED SAVING IN USE OF CONCRETE CRIBBING ON TWO-LEVEL FILLS

Tests as to the settlement and movement of the cribbing for a period of nine consecutive months show movements which could not be detected with the eye and are practically negligible. The photograph shows one of three types now under test. The cost thus far has been about 20 per cent of a retaining wall of the same height.

This crib wall was constructed of 6-ft. headers, 8-ft. stretchers and a front batter of 1:12, and has formed a very stable and substantial-looking wall.

The cribbing was placed and tests of it were made under the direction of R. H. Ford, engineer of track elevation.



APPEARANCE OF CRIBBING AND JUNCTION WITH BRIDGE AT EIGHTIETH STREET

More Proof of Need for Supervision of Dams

California Structure That Failed Two Years Ago Violated at Least Four Established Principles of Dam Design

By RALPH BENNETT
Engineer, Los Angeles

SOME two and a half years ago there was in Southern California a dam failure that, though fortunately unattended by loss of life, illustrated most forcibly the need of proper supervision over this class of structure. The dam in question violated at least four rules of dam design, in spite of the fact that a proper structure could have been built for less money.

At about 6 o'clock on the morning of Feb. 21, 1914, there failed in Sepulveda canyon, near Sawtelle, Los Angeles County, Cal., a 65-ft. earth dam having a thin concrete core wall. Considerable property was damaged, but no lives were lost. Portions of the concrete core wall were swept downstream to distances of more than 2200 ft. There were no eyewitnesses of the occurrence, and in order clearly to connect up the dam failure with the damage it became necessary to reconstruct from the physical evidence the conditions which existed during the catastrophe.

The dam had originally consisted of a concrete wall, without useful reinforcement, standing 60 ft. above a rotten bedrock of soft shale. This core wall was 2 ft. thick at the top and not more than $3\frac{1}{2}$ ft. at any point. It had a horizontal angle of 20 deg. downstream near the deepest section. Most of the earth backfill was carried to within a few feet of the top of the wall, but at places it was more than 9 ft. below. It consisted of silt, debris and earth, and was but slightly compacted. The slope was about $1\frac{1}{2}$:1 on both faces.

A small spillway was provided, but the structure when filled showed signs of such serious distress that it was drawn down and a notch 26 ft. deep and 12 ft. wide cut in the core wall near the center. As no opening was cut lower in the wall and the 16-in. drain could handle not more than 26 sec.-ft., the waters of any considerable storm, flowing from the 1688 acres of steep hills above, had to pass over the lip of this cut and over the downstream fill. This discharge occurred during one or two small storms without washing away sufficient of the fill to release the core wall, but the very severe and continued storm of Feb. 18 to 21, 1914, completed the work and the dam failed.

PROBABLE RUNOFF

Using the rational formula for runoff, the maximum discharge from runoff across the dam site would not have exceeded 1700 sec.-ft., but was probably not more than 700 sec.-ft. judging from the channel evidence, above the reservoir. In this locality the flat bottom of the canyon is covered with brush and grass, through which there is a small weed-grown channel showing no evidence of heavy flows. The condition starting at the dam and for a long distance downstream was entirely different. Brush and small vegetation had been entirely swept away, while trees and shrubs were wrenched and damaged. The channel was clean-swept and scoured. Brush and debris were lodged in the trees and on rocks at a very considerable elevation above that of any ordinary flood. Most of the heavy blocks into which the core wall had disintegrated were swept downstream considerable distances.

The canyon for some thousands of feet below the dam was cross-sectioned and levels were run. Definite high-water indications were noted and located with reference to the cross-sections. From these data and a value of n assumed to suit the channel the maximum flow was computed. Except for one bend of nearly 180 deg. close to the dam the channel was fairly straight.

After careful consideration of the bottom and side conditions and the corresponding features of known channels, a coefficient of $n = 0.035$ was selected. The conditions were rather more favorable, but the channel may have been considerably obstructed by small growth at the time of the passing of the crest, due to the sudden failure of the core wall.

The flood arrived at at the different points at which definite flood marks were found varied from 8000 to 12,000 sec.-ft. without reference to the distance from the dam. Apparently the minor turns in the channel had a considerable effect. As only well-defined brush or heavy débris marks were used, the highest mark may nct have always been taken.

PARTS OF CORE WALL CARRIED FAR

The flood had carried certain well-identified masses of the core-wall concrete long distances. The movement of stones, etc., in a stream is subject to approximate calculation. It must be assumed that the masses are of shapes such that they can be rolled along the stream bed and that they are submerged. Both these conditions could be satisfied by many of the blocks.

As a typical case, there was a concrete mass 2x2x7 ft. about 2258 ft. below the dam. The stream velocity required would be $V = 5.67\sqrt{ag}$ (Kent, page 566), where a is the mean diameter and g the specific gravity of the mass. Substituting $V = 5.67\sqrt{2.5 \times 2}$, $V = 12.5$ ft. per second.

At this point the cross-section of the flood channel is 618 sq. ft., so that the flow must have been 7725 sec.-ft. The channel calculation for the same point gave 8000.

The core wall failed in a roughly trian-

BREAK IN CORE WALL

gular shape. It had been trenched into the shale of the site about 5 ft., but very close to the edge of a small drop. When the wall failed the lower portion sheared this thin shoulder entirely off. One of the blocks of concrete, 3x11x33 ft., was carried directly out from the break 160 ft. and lifted above its original elevation. These and other minor considerations make it evident that the core-wall failure must have been instantaneous. Under this assumption a triangular weir existed until the basin was nearly empty.

Water must have been pouring over the lip of the cut in the core wall to a depth of several feet, but it is sufficient to assume the water level at the lip. This would give an initial depth of 30 ft., which would produce a flow of 13,000 sec.-ft. The rate of discharge would decrease rapidly as the reservoired water lowered.

The dimensions of the basin call for about 5,568,000 cu. ft. of water at this height. Of this, 2,900,000 cu. ft. went out in the first 6 minutes and lowered the level 10 ft. Most of the remaining storage was discharged in the next 33 minutes, at the end of which time the discharge had fallen to 480 sec.-ft., which flow may have continued for some hours, but slowly decreasing.

The sharp crest of this wave reached a power house on the lower stream at 7 minutes 3 seconds after 6 a.m. and extinguished the boiler-room fires. Within half an hour the water had mostly disappeared and the plant was able to relight.

SUPERVISION NEEDED

There can scarcely be a more perfect proof of the need of state or national supervision of this class of work than this structure. As built it was doomed to failure from unstable core wall, insufficient fills, improper fill materials, insufficient spillway capacity, inoperative spillway gates. When these conditions caused incipient failure the only time the basin was allowed to fill, the cutting of an overflow notch in the core wall at the middle of the work destroyed any slight chance of survival which had existed.

The site is a favorable one, and a single arch containing much less material than the useless core wall of this structure could have been put up for a much less sum.

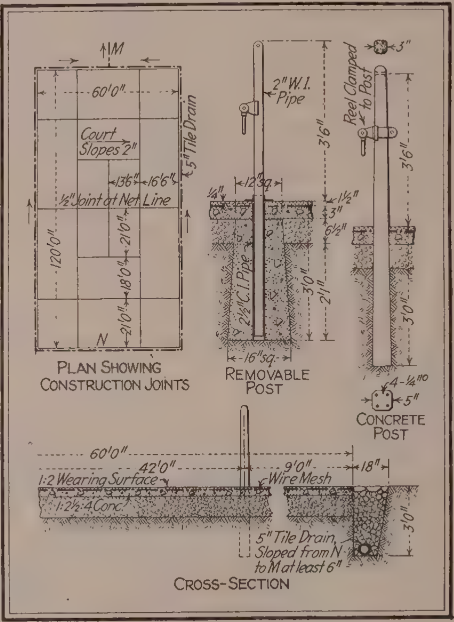
Question of Skilled Help a Difficult Problem on Pennsylvania Highway Work

The question of experienced help, including engineers, superintendents, foremen and even laborers, is a difficult problem with the Pennsylvania State Highway Department, according to a statement made by William D. Uhler, chief engineer, in a paper presented at the meeting of the mechanical and engineering section of Franklin Institute, held in Philadelphia recently. "Because road work along modern lines is in its infancy," he explained, "it is necessary to educate the forces, and one of the chief troubles in holding together the necessary road organization is that it is impossible—in fact, impracticable—to provide work for them during the full twelve months of the year. This is because the character of the work will not permit of continuous employment, and it becomes necessary, usually, to lay off approximately 75 per cent of the force at the close of the working season. Consequently the skilled assistants look for more permanent work."

How to Build Concrete Tennis Courts

Cement Association Offers Suggestions—Courts at Chicago Club Used for Tennis, Dancing and Skating

CONCRETE TENNIS COURTS now under construction in Chicago, Rockford, Ill., Minneapolis, Pittsburgh and other places give evidence that a new field is being invaded by reinforced-concrete construction. The accompanying photographs show the appearance of the courts at the South Shore Country Club, Chicago, while the drawing illustrates typical details proposed in a suggested design by the Portland Cement Association. The finished courts shown in the illustration have been surfaced by a rotary surfacing machine for the purpose of giving a perfectly smooth finish which can, it is stated, be waxed when desired and used for a dancing floor. Other concrete courts for the Chicago Tennis Club will be finished with curbs high enough to allow flooding with water in the winter season for skating purposes.



DETAILS OF CONCRETE TENNIS COURT

Specifications covering the preparation of the sub-base and the laying, finishing and hardening of the court have been prepared by the Portland Cement Association. As

SOUTH SHORE COUNTRY CLUB TENNIS COURTS AT CHICAGO—POLISHING FOR USE AS DANCE FLOOR illustrated by the drawing herewith, the concrete base is a 1:2½:4 mix, wet enough to flush readily under slight tamping, but which can be handled without causing a separation of the coarse aggregate from the mortar.

The reinforcement of wire mesh or wire fabric is placed lengthwise of the courts and not less than 1½ in. from the finished surface. A wearing course of 1:2 mortar mixed dry is placed 1½ in. thick on top of the 3-in. concrete base before the latter has hardened. Construction joints, as indicated on the plan, should coincide with the court lines. The surface is worked with a wood float and brought to a smooth plane by the use of a steel trowel. A grade of 2 in. transversely is provided for drainage.

Clay subgrade should be excavated to a depth 11 in. below the finished surface of court, while a sand or gravel subgrade will support the slabs without more than a 4½-in. excavation. Fill should be of cinders or coarse gravel. The subgrade should be uniformly compacted before a fill is started and the fills made of compacted layers not over 6 in. thick.

Finally, the usual precautions to insure proper curing conditions should be taken—the surface covered with at least 1 in. of wet sand or 2 in. of wet sawdust, and kept wet by sprinkling for at least ten days.

Letters to the Editor

Comment on matters of interest to engineers and contractors will be welcomed

The Pioneer in Water-Right Laws

Sir: From time to time my attention has been called to articles appearing in the technical journals relating to the water-right laws of Western states. For some reason the history of this kind of legislation seems to be ignored and prominence given to one or two states which have more recently adopted a modern administrative system, following the example of many that have taken this important step in earlier years.

It is evidently not generally known that Wyoming, first by constitutional provision in 1890 and then by legislation in 1891, laid the foundation for a technical administration of water resources. Wyoming had no other state to guide her when this important departure was determined upon. She was fortunate in having the advice of Elwood Mead, who must be regarded as the great leader in this kind of work. He outlined the constitutional provisions and framed the law based thereon. He administered the law for ten years. His experience can never be paralleled. To select wise principles governing the administration of streams after the courts had been in full possession of the field for years is a task that demands courage and ability.

The principles embodied in the water laws of Wyoming have not been improved upon by any other state. No other state has been able to define the important principles as plainly and as definitely. Litigation has been eliminated in Wyoming in so far as water-right controversies are concerned. Water rights are determined by an administrative board and the water user is protected without cost. The water right belongs to the use. The water always belongs to the state. Speculation is impossible after the right accrues.

Those who have followed the early history of water-right legislation are pleased that the Wyoming system has been adopted in so many states and that it has brought peace, justice and contentment wherever it has been introduced. As a matter of history and to make a record of one of the greatest of engineering achievements in this country, it should be remembered that Elwood Mead, an engineer, discovered the principles which underlie this kind of legislation. It should also be recorded that the engineer has been responsible for the introduction of this kind of legislation in all Western states and the laws thus provided have been successful because they contain wise principles and because they are administered by technical men who fully appreciate the problems involved.

Clarence T. Johnston.
Ann Arbor, Mich.

Blueprint Paper, Like Hair, Can Be Rejuvenated with Peroxide

Sir: Engineers and draftsmen in the outlying districts depending on sun-printing outfits for blue-printing are often annoyed by finding their supply of blueprint paper "gone bad" when most needed. I have found that such paper may be used by printing and washing in the usual manner and then applying hydrogen peroxide with a small sponge. This will bring out the print in detail.

Peroxide as an intensifier has the advantage of being non-poisonous and may be obtained at any corner drug store.

R. L. Longshore,
Deputy Surveyor, Adams County, Indiana.
Decatur.

Sewage Disinfection

Sir: An editorial entitled "Sewage Disinfection" appears on page 278 of the Engineering Record for Sept. 2. This editorial contains the following noteworthy sentence: "This (chlorine disinfection) method of destroying bacteria, while often difficult, has limitations which may not be safely disregarded."

My experience with liquid chlorine has been disappointing, especially in cold weather where the temperature of the sewage (effluent from Imhoff tank) and water have dropped below 55 deg. Fahr. At such low temperatures the bactericidal action or efficiency of the liquid chlorine decreases in a marked degree, and at lower temperatures the chlorine makes a taste in the water that is quite as noticeable as the tastes which are produced by bleach.

In view of this situation it seems to me that an effort should be made to find some catalytic agent which can be applied to increase the efficiency of the chlorine when the conditions are adverse to its germicidal action. The addition of lime has been suggested and tried out in a practical way by the use of bleaching powder, but always with the result that bad tastes develop in cold weather.

A far more serious condition goes with this, however, because the good results obtained in summertime create the impression in the minds of the average person that water treated with bleach or liquid chlorine is safe to drink at all times. As a matter of fact, quite the contrary may be the real truth, with the unfortunate result that epidemics of dysentery and typhoid fever sweep through communities that are living under a false sense of security.

I hope that you will take advantage of your wide connection among engineers and sanitarians to urge investigators to devise means for increasing the bactericidal action of liquid chlorine in cold weather and to caution consumers of public water supplies that the simple and cheap installations required for bleach or chlorine sterilizing outfits can be relied upon only as finishing processes, following efficient devices for water or sewage clarification or filtration.

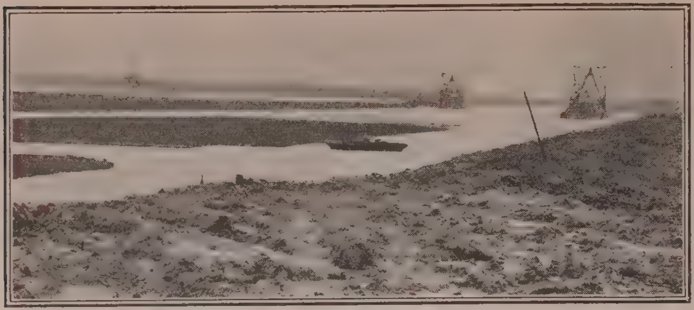
William R. Copeland,
Chemist in Charge, Milwaukee Sewage Testing Station.
Milwaukee.

Justice to the Contractor and the Engineer

Sir: The opinions voiced by H. G. Shirley in his letter appearing on page 180 of your Aug. 5 issue, and by R. M. Stamper on page 270 of your issue of Aug. 26, on "Justice to the Contractor," are well taken, but recent experiences lead the writer to believe that much of the so-called justice the contractors desire is in reality nothing more than a "balm" for "injured feelings" which come on after reading the specifications on being awarded the contract.

Now it is not the writer's intention to say that all contractors do not read the specifications carefully before bidding, but from the way nine out of ten make up their proposals (even when a blank proposal form is included in the specifications) it would appear that they care little as to what the specifications call for. If the specifications call for certain things which are a little out of the ordinary, the contractor (not the engineering contractor, who does things on a scientific basis) takes the notion into his head that possibly the engineer doesn't know what he wants (and at that, he is sometimes correct) and he puts in his bid based on the usual way of doing things, but saying nothing about it. If the job be a large one, the contractor who carefully estimated it is out of the running because some contractor, whose office is under his hat, did not enter his bid as requested to. The contract is let to Mr. Wiseone and he starts to do the work as he bid on it. Then when the "horrid boy inspector," or even a superintendent with more experience than the contractor, calls his attention to the error of his ways as indicated by paragraph so-and-so of the specifications, he raves about the injustice of making him do things according to specifications when his practice for years had been different, whether right or wrong.

Yes, this is an injustice to the contractor, not to the "wise one," but rather to the contractor who bid as the specifications asked him to, inflicted by one of his contemporaries. If the "successful" bidder had been honest with himself and the engineer, he would have stated in his proposal, or before signing the contract, the



PILOT CUTS LEAVE 200-FOOT CORE—BOOM 175 FEET—BUCKET 4½ YARDS

THE ANTIOCH AND THE MONTEREY MAKE PARALLEL CUTS ALONG CORE

details of the departure he wished to make from the specifications, but fear of losing the job prevents this, and during the interval between signing the contract and starting work he hopes that a boy inspector will be placed on the job on whom he can "slip it over" or whom he can make the "goat" if caught up.

This little illustration may seem exaggerated to some, but I am confident that engineers in general will bear me out in this contention. The point I wish to make is that the time to kick about faulty specifications is before signing the contract of which they are a part, and not afterward. If contractors would refuse to enter on work having loosely drawn or deceptive specifications, or add a big percentage for contingencies, the author of them would soon see the light and play fair or quit business.

This question of horse sense is only relative and depends entirely upon whether the interpreter is a thoroughbred or a mule, figuratively speaking. To the unfair bidder horse sense means the allowance by the inspector of stretching of the specifications until they crack, to let him do the work as he bid on it, while to the contractor who gave the engineer credit for knowing what he wanted, it means something entirely different.

I have come in contact with young college-graduate inspectors and the so-called "practical old-timers," and to my mind, the technical graduates with proper instructions from their superiors are on the average as far ahead of the others in horse sense as a race horse would be in a race with a Percheron, if the deciding be done by competent judges. The number of ordinary contractors who can intelligently read and interpret specifications is indeed few as compared with the number of college-graduate inspectors who are capable of so doing. In a way the inspector who, because of inexperience, demands that the specifications be lived up to is a blessing to the profession, for if his insistence on work being done as specified causes trouble, then reform is necessary in the writing of specifications or in the manner of bidding, and not in the inspection. My experience has been that generally the longer a man is engaged in superintendence and inspection the more lax he becomes in his enforcement of specifications, since he is wont to make too great allowance for the "common-sense" interpretation thereof, and to take the easier way of giving in to the contractor who is on the job constantly rather than uphold the engineer, who may visit the work occasionally. After a contractor deals with one of these fellows who make inspecting their life work (or vocation), the way of the young graduate is hard indeed.

The writer's intention is not to create the impression that engineers are never in error, but rather to present a phase of this much-talked-of subject which is seldom brought out. Then also let me make clear that by ordinary contractor as herein used is meant, not the engineering contractor who carefully analyzes every bid, but the fellow who is wont to take chances and lump things together rather than consider every item entering into the make-up of a structure in detail. As in everything else, there are two sides to this question of justice, and instead of talking about "justice to the contractor" let us make the proposition mutual and revise the slogan to read "justice to the contractor and the engineer," which latter implies "owner" also. No real progress will be made by one side heaping the onus of conditions on the other, for there are just grievances on both sides which only a mutual understanding between the great body of engineers and that of the contractors can remedy.

Chicago. ALBERT M. WOLF.

How Wide a Canal Can Available Floating Dredges Dig?

SIR: The writer has studied with much interest the article in the Engineering Record of Aug. 5, page 174, on the Little River Drainage District of Missouri. The surprising statement is reiterated that a canal with "a base width of 123 ft. is practically the limit for economic construction with floating-dredge equipment now built."

The Knights Landing Cut (see the Engineering Record of March 15, 1913, page 298) is now practically complete. It has been constructed throughout with floating-dredge equipment with a bottom width of about 400 ft. About 60,000 yd. at the upper end, where the width increases to 600 ft., was rehandled. On the remainder of the work material was taken direct from the excavation and placed in the spoil banks without rehandling. This was accomplished without difficulty even where the depth exceeded 14 ft. and the cross-sectional area 220 cu. yd. per linear foot. The bulk of the work was done with clamshell dredges of the type commonly used in California, with buckets of from 4 to 5 cu. yd. capacity and booms 170 to 190 ft. in length. These machines average from 2500 to 3000 cu. yd. per day of 22 hours. The largest machines have booms 240 ft. in length, with 6-yd. buckets. All conceivable classes of material are handled with ease. In heavy timber it is cheaper to pull out the large stumps. With the larger machines material can easily be placed without rehandling 300 to 350 ft. from the point where it is excavated. Unit costs, varying with the class of material, will average from 5 to 10 cents per cubic yard.

The writer has studied and observed work of this character along the Mississippi River, and has been utterly unable to understand why heavier equipment with greater capacity and longer reach is not in more general use there as it is in California on similar work.

FRED H. TIBBETTS,
Haviland & Tibbetts, Civil Engineers.
San Francisco.

[Mr. Tibbetts' inquiry was submitted to William A. O'Brien, chief engineer of the Little River Drainage District. Mr. O'Brien states that the discussion arises from the misunderstanding over the type of dredge. What is referred to in the article, although it is not definitely stated, is a dipper dredge. With the machine of this type, having 90-ft. boom and 4½-yd. bucket, the

THE THOR AND THE ARGYLE ON 400-FOOT CANAL 13 FEET DEEP—NO MATERIAL REHANDLED

123-ft. bottom width and 10 to 12-ft. cuttings are the limit for economical construction. There are no dredges of this type of larger size, and for a wider ditch, material would have to be rehandled.

Further he says: "A combination plant consisting of a dipper dredge and clamshell could be used on prisms of greater width. In fact, the installation of such a plant is contemplated by one of the Little River contractors. If Mr. Tibbetts could give us some information relating to the operation of clamshell or orange-peel dredges when working in heavy timber, it would be appreciated."

The query was put to Isham Randolph as to why these large-size machines had not been used in the Mississippi Valley. He replied that the expense of the machines had seemed too great to the contractors for the amount of work they could expect to do with them.—EDITOR.]

Beware of a Confidence Man

SIR: There is a man traveling around over the country calling on engineers and people in engineering work representing himself as not having had employment for the last few months, and as having been laid up in a hospital with typhoid fever or some other ailment, and with a view of getting enough money to tide him over until he hears from home he is "making a touch," or trying to do so, on representatives of manufacturing concerns, engineering organizations and the like.

The writer recently had an interview with him under the name of E. Byrne. Mr. Byrne (?) stated that he was assistant engineer of inspection on concrete work at the large Keokuk hydroelectric plant. He also advised that he was a classmate of one of the members of our organization located in some other city. He reported himself as being a graduate of Lehigh University.

He is a fluent talker. He is about 33 to 35 years of age, weighs about 160 lb., is about 5 ft. 9 in. tall, dresses well, presents a good appearance and has a very convincing argument. X. Y. Z.

Strength of Clamped Splices in Reinforcement Bars

SIR: The writer believes that the paper by E. L. Lasier, entitled "The Strength of Clamped Splices in Concrete Reinforcement Bars," presented at the recent annual meeting of the American Society for Testing Materials, has not been properly commented on by engineers. He has been strengthened in this belief by the appearance of an advertisement of a firm which manufactures bar splices.

The author of the paper states that "clamped lap splices embedded in large masses of concrete undoubtedly can safely withstand a unit load equal to the unit stresses in steel reinforcement." The manufacturers quote the foregoing statement and we may see in the near future a large number of contractors and engineers using spliced reinforcement. For large bars it has been stated that the cost of the splices and labor will be less than the cost of the additional length of bar required for bond.

The author's experiments plainly show that the ratios of load at first slip to yield point of bar for clamp splices embedded in concrete varied from 53 to 83 per cent. We know from experiments that by using embedments of proper length for bond 100 per cent efficiency can be secured. Assuming the yield point of the steel to be 32,000 lb. per square inch, and a fiber stress of 16,000 lb. per square inch is used in designing, the steel when lapped can be depended upon to hold in the concrete until the elastic limit is reached, thus giving a factor of safety of two, based on the elastic limit.

It is poor engineering to use a form of splice in which the ratio of slip to the elastic limit varies from 53 to 83 per cent when 100 per cent can be obtained by methods universally approved.

We are to assume that in the laboratory tests the greatest care was used, yet splices cannot be depended on safely to withstand a unit load greater than the allowable unit stress in the steel reinforcement bars; consequently there is no factor of safety. It is not reasonable to assume that all splices in the field will be better than the bar splices made in the laboratory, and a warning should be issued against the use of clamped splices for reinforcing bars.

The writer noticed in several cases that bars were spliced by welding. In concrete arch bridges where the unit stress in the reinforcement is very low there may be no danger in welding the main reinforcing bars. In beams and girders in which the steel will be stressed to 16,000 lb. or more per square inch, the splicing of bars by welding is a dangerous practice.

ERNEST MCCULLOUGH,
Consulting Engineer.
Chicago.

[A copy of the foregoing letter was submitted to Mr. Lasier, who comments on it as follows.—EDITOR.]

SIR: The letter from Mr. McCullough will, of course, only be commented upon from the standpoint of the testing engineer.

The undersigned has not yet had the opportunity of seeing the advertisement referred to. It must be remarked that the conclusions drawn in the paper under discussion were guardedly and advisedly worded in view of the limitation of the tests; no generalizations were stated, and the conclusions referred only to splices similar in nature to those tested.

No tests were made upon splices consisting of welded bars.

The clamped splices were prepared, as stated in detail in the paper, not with special laboratory care, but using the same practice which could and should be duplicated on the actual work.

It is desired to call attention to one phase in particular of the above letter. Mr. McCullough assumes reinforcement steel of a soft structural steel grade, having a yield point of 32,000 lb. per square inch. No tests were made on splices of bars of that grade. It is distinctly stated in the paper that the reinforcement steel in all cases consisted of 1-in. square cold-twisted bars, having an average yield point of, actually, 60,360 lb. per sq. in. (specification, 55,000 lb. per square inch minimum yield point.) It is not fair, therefore, to criticise the tests reported upon, assuming steel reinforcement of a grade entirely different from that used.

As a matter of fact, the average value of load at first slip obtained for the splices tested, such splices being embedded in a comparatively small mass of concrete, was 39,300 lb., with a minimum value obtained of 32,000 lb. and a maximum of 50,000 lb. That is, assuming an allowable fiber stress in the reinforcement of 16,000 lb. per square inch, the factors of safety, based on the values of load at first slip for the tests made and reported upon had as an average 2.5, and minimum and maximum values of 2.0 and 3.1 respectively.

For a more complete discussion of this subject, those interested are referred to the September and October, 1916, issues of *Concrete*.

E. L. LASIER,
U. S. Bureau of Standards.
Washington.

Worn Macadam Roads Repaired by Tar Spraying

SIR: I note with interest the remarks published by Professor McNeilly in your issue of Sept. 2, page 281, regarding the repair of macadam roads by giving them a light application of a light tar oil, and from the experience that has been gained in the highway department of Wood County, Ohio, I may add that this method has been practised for some years.

From the illustrations accompanying the article it appears that the binder applied by the penetration method to the macadam has fallen short of its purpose through faulty construction, and instead of making a true binder has only formed a carpet coat. This may be true of either tar or asphalt. The fact that the screenings contained a large percentage of fine dust would not seem detrimental to the asphalt, and the probabilities are that the asphalt was "killed" before being applied to the road, through overheating or in any other of the many ways that a road binder may be impaired.

The "picking up" referred to is not a fault of the penetration method road alone, for it occurs wherever the surface becomes broken in any class of road.

From our observations it would appear that where a type of pavement is to be selected some of the peculiarities of the materials in question must be considered, and not a random selection of materials made; and it is highly probable that by using a waterbound roadway of the grade of limestone reported, as good results could have been expected as with the use of the asphaltic binder on a roadway with light traffic.

R. M. STROHL,
Deputy County Engineer, Wood County.
Bowling Green, Ohio.

862 Workers Killed This Year in Pennsylvania

Workmen's compensation to be paid to dependents of 290 workers killed in industrial accidents in Pennsylvania during the first five months of 1916 aggregate $742,962.75. That amount is for fatal cases and does not include cost of medical attendance and compensation. During the first five months of the year 862 workers were killed, including one civil engineer. It is estimated that when all the compensation agreements are perfected the total amount of compensation for fatalities will approximate $1,500,000. Up to June 1 of this year the total number of compensable accidents reported to the Workmen's Compensation Bureau at Harrisburg, Pa., numbered 26,531. Four thousand compensation agreements have been paid in full and 13,000 compensation agreements have been approved. There have been 397 petitions filed by injured employees claiming compensation.

HINTS FOR THE CONTRACTOR

Details Which Save Time and Labor on Construction Work

Other articles in this issue of interest to contractors and construction engineers are indexed in the Table of Contents

[*Contributions to this section are solicited, and if found available will be paid for. They must be* SHORT, *and should be accompanied, if possible, by photographs or sketches.*—EDITOR.]

Two-Way Motion and Revolving Hammer Cage on Land Drivers

A TYPE of land driver with two-way motion leads lengthwise of the underframe to bring the hammer parallel to the two long lines of sheeting to be driven, and carrying the hammer in a revolving cage in front of the leads so that it could drive sheeting on an arc, proved very successful in constructing the land wall of the cofferdam for lock No. 2 on the Cape Fear River, described on page 325 of last week's issue. The lower carriages of the drivers ran on tracks spanning the width of the cofferdam cells. A third track back of the rear wall of sheeting carried an extension of the underframe on which the hoist was mounted. Steam for both the hammers and the hoisting engines was provided from a central boiler plant. Each driver was equipped with two 2-in. jets. The pumps which supplied these jets were mounted on barges tied up at the points where the drivers were working.

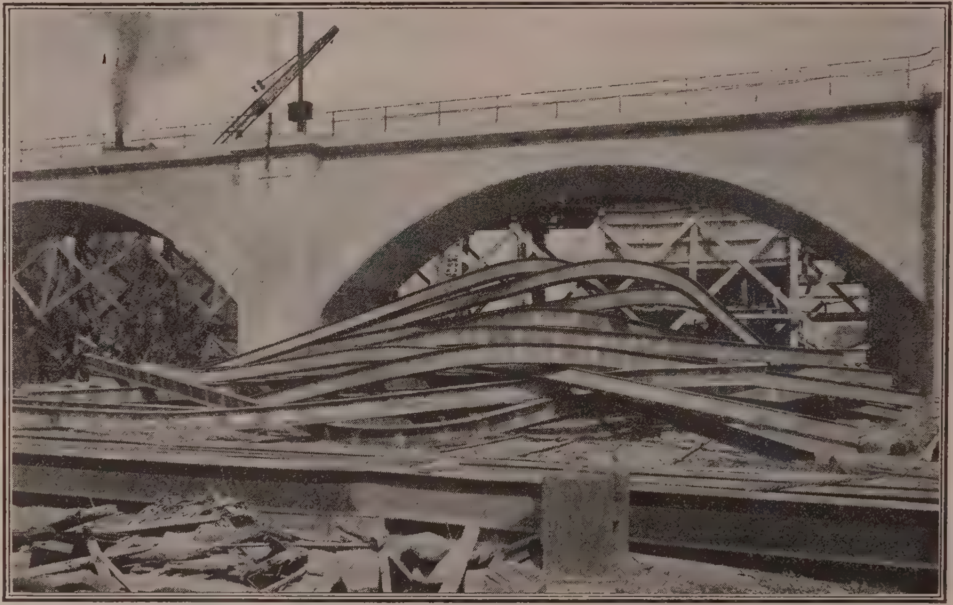
The sides of the sheet-pile pockets next the river were curved, and on one of the drivers the frame in which the hammer was suspended in front of the leads was constructed so that the hammer could be turned at any angle to follow the curve of the sheeting. The cage on the other driver did not have this revolving feature, but was useful where it was necessary to over-reach piling partly driven in making the closures of the pockets.

The work was done with government plant and forces under the immediate direction of Norman M. Chivers, assistant engineer, and under the general supervision of Capt. C. S. Ridley, Corps of Engineers, U. S. Army.

DRIVING PILES TO MORE THAN 40 FEET PENETRATION, THESE RIGS AVERAGED 16 A SHIFT

Bent I-Beams Hung Over Fire Straighten of Own Weight

A LARGE number of bent 15-in. I-beams were straightened at Harrisburg, Pa., by F. P. Kemon, superintendent for the Robert Grace Contracting Company, engaged in building the Cumberland Valley Railroad bridge described on page 340 of this issue, by hanging them one at a time between two ginpoles over carefully built wood fires. Each end of each 72-ft. beam was suspended by a set of falls. These falls were attached to the tops of two ginpoles leaning toward each other and each guyed with three lines. In this way there were no guys directly over the fire. The beams were suspended belly up in the case of light kinks, and belly down when badly bent, with the bend resting on the fire, so as to straighten of their own weight when heated. It was necessary to guy them sideways with small wire lines to keep the web as nearly as possible in a horizontal position. The fires, built of scrap lumber from the job, were tended by an experienced blacksmith, who took great care to avoid burning any part of the beams.



I-BEAMS WERE STRAIGHTENED SUFFICIENTLY FOR USE IN TRESTLE BY HANGING OVER FIRE

The work was very successful, many beams as badly bent as some of those in the photograph being restored to practically perfect straightness. A number of the more badly bent beams could not be quite straightened, but were restored near enough to their original condition to make it safe to use them in trestle construction.

The trestle in which the beams were employed was about 1500 ft. long and extended entirely across the east branch of the Susquehanna River. The river bed is scoured bare, and the framed trestle bents rested directly on the rock. The entire trestle, which was upstream from the new bridge, was carried out by a severe and unexpected flood on June 18, practically all of the stringers being bent around the upstream ends of the piers. As soon as the water went down, the stringers were fished out by a locomotive crane on the main-line track. The work of straightening them on the island proceeded so rapidly that it was possible to rebuild the entire trestle and start concreting at its far end in less than six weeks after the flood. Aside from the present high price of steel, it is doubtful if a sufficient number of stringers to replace the bent ones could have been delivered to the job within this time.

Railroad Sold to Philippine Government

The sale of the Manila Railroad to the Philippine government was ratified Sept. 8. The price was $4,000,000. The road, the only one on the island of Luzon, has 350 miles of track.

NEWS OF THE WEEK

Passing Events in the Civil Engineering and Contracting Fields

Suspended Span of New Quebec Bridge Falls Into River While Being Hoisted Last Monday Morning

Broken Intermediate Shoe Casting Suspected as Cause—Span, Supported on Diagonally Opposite Corners, Crumples and Slides Into Stream—Operations Until That Moment Unusually Successful

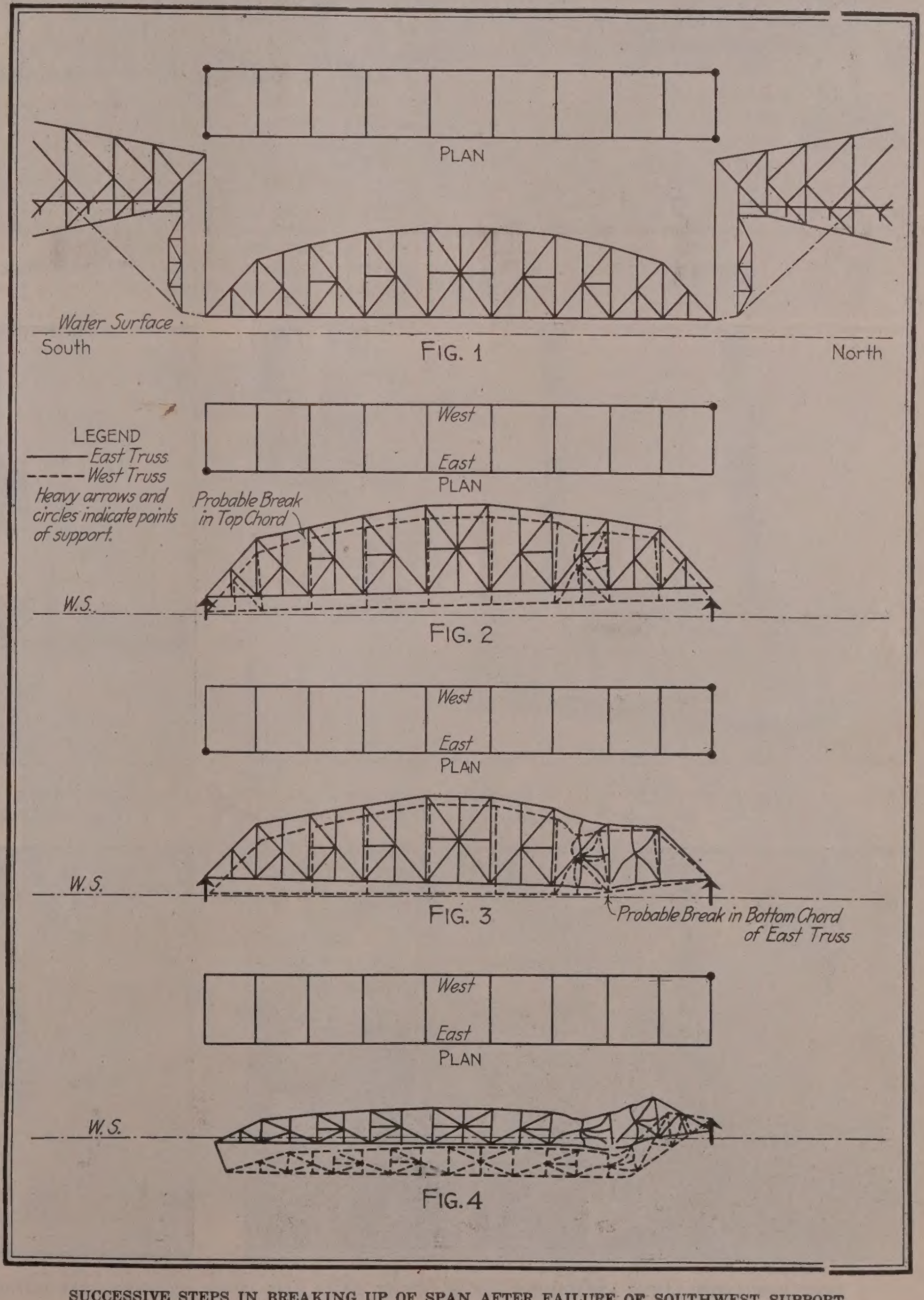
The suspended span of the new Quebec Bridge while being hoisted to position last Monday morning fell from its hangers and now lies a wreck on the bed of the St. Lawrence. Until the instant of failure the remarkably worked-out program was successful in every particular. The floating out from the erection site, the placement ready for hoisting, the connection of the truss to its lifting mechanism, the releasing from the scows, seven or eight cycles in the jacking operations—all had been performed in accordance with schedule. Then when the hosts of spectators were congratulating the engineers over the success of their work, when most of the responsible men, confident of the overcoming of all difficulties, were relaxing from the strain which so serious an operation imposed, the huge structure, without warning, slipped from its supports and in a flash disappeared in the river. The failure occurred at 10.50 a. m., 80 minutes after the barges had floated free and lifting had begun.

The sequence of failure was probably as follows:

The southwest corner of the span slipped out of its supporting stirrup, throwing the weight of the structure on the southeast and northwest corners. The lateral system and sway bracing developed sufficient resistance under shear to crumple the west truss in the center of its north half. At the same time, or just previous, the top chord of the south half of this west truss pulled apart from its own weight. Simultaneously, probably, the unsupported north half of the east truss also pulled apart, or began to do so. The failure of the north half of the west truss robbed the mass of its diagonal support of the instant previous and allowed the north shoe of the east truss to drop back with considerable impact upon its stirrup, causing the north half of this truss, doubtless already weakened, to crumple. An instant later the southeast lifting girder tore its way free from the structure, already turning upstream, or west, and partly in the water. At this moment, apparently, both north corners still rested in their stirrups. Which of these left its seat first the evidence does not yet clearly indicate, but whichever did, snapped first the mooring lines (none of which had been cast off), exerting the greatest pull on the east corner of the mooring truss, breaking in the instant previous the east set of heavy falls attached to the lower corner of the mooring truss and to the lower chord of the cantilever. This movement severely stressed this truss, warping it permanently while it was still held by the west set of falls. By this time the north pair of hangers had undoubtedly been kicked far back, so that when the last corner of the suspended span let go it was under or even north of the mooring truss. The two lines from this corner must have swung the mooring truss north, letting it go as they snapped, so that it fell back and broke its west set of falls by its own weight. Eleven lives, all those of workmen, were lost in the failure.

This account of what happened on the fatal Monday morning at Quebec, after everything in the unprecedented operation of raising this 5100-ton span of nickel steel had gone so smoothly that most of the distinguished engineers present had left for lunch, is based on testimony of eyewitnesses, photographs and conditions after the accident, the information having been gathered by two representatives of the Engineering Record, who were at the site. This evidence will be presented in detail below, but for its understanding a brief review of the method employed and of the operations under way at the time is necessary. This method, which was most unusually successful in every detail up to the moment of the collapse, will be described more fully in a subsequent issue of the Engineering Record.

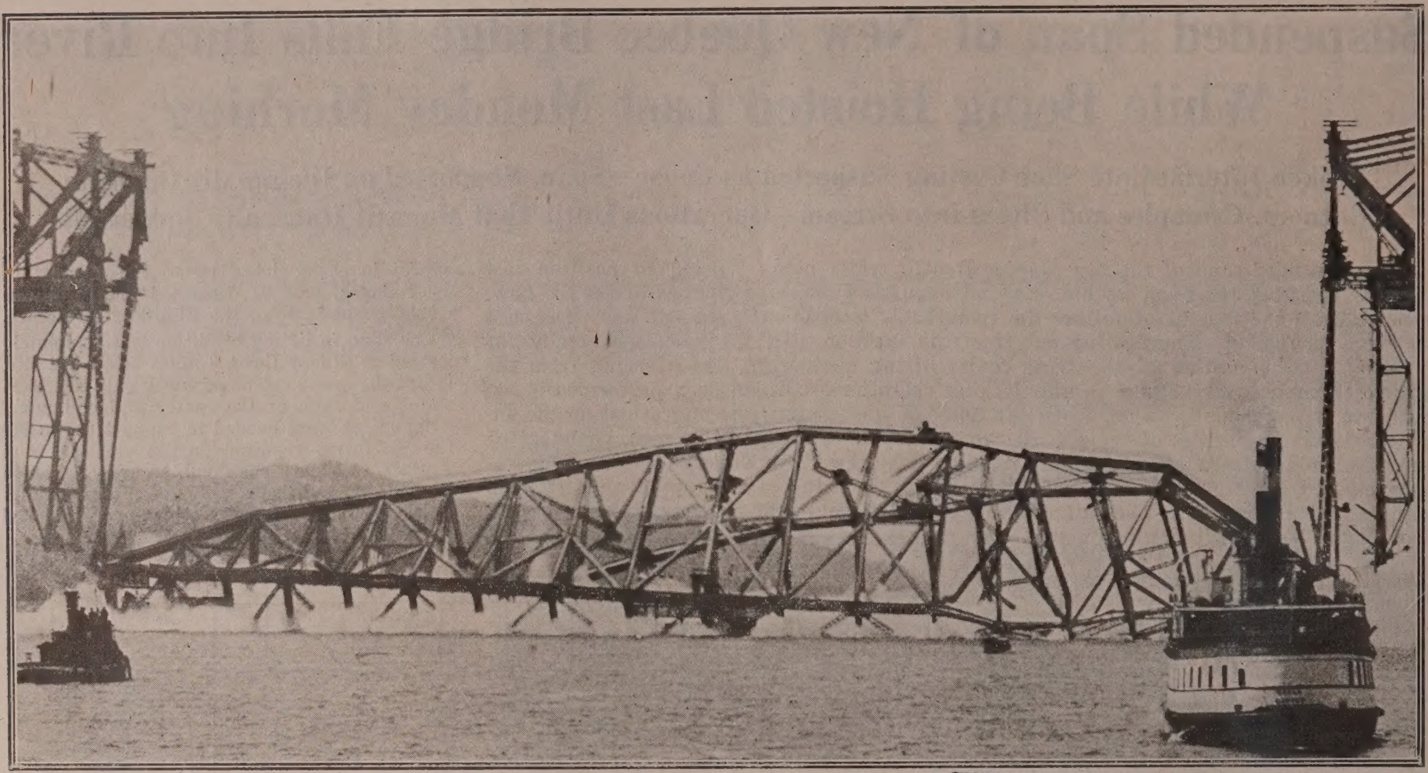
The span in lifting condition was completely erected at Sillery Cove, 3 miles below the site, except the floor system, of which only the floorbeams and such of the center and end panel stringers as were needed to support the hoists and platforms required during erection were in place. Beneath each end, securely fastened together, was placed a group of three specially built steel frame barges, which were blocked



SUCCESSIVE STEPS IN BREAKING UP OF SPAN AFTER FAILURE OF SOUTHWEST SUPPORT

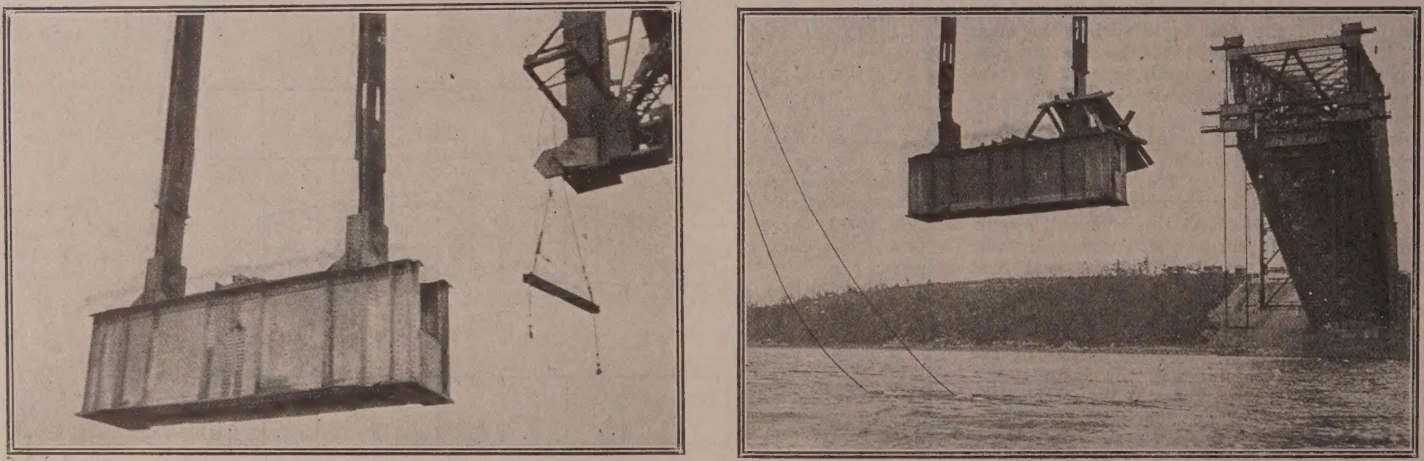
Fig. 1—Just before accident. Fig. 2—Southwest support gone. Fig. 3—Failure of east truss. Fig. 4—Final plunge.

These Photographs, Taken During, Before and After the Fatal Accident to the Suspended Span of the Quebec Bridge, Show the Lifting Mechanism and the Manner in Which One Corner Jumped from Its Support, Precipitating the Plunge

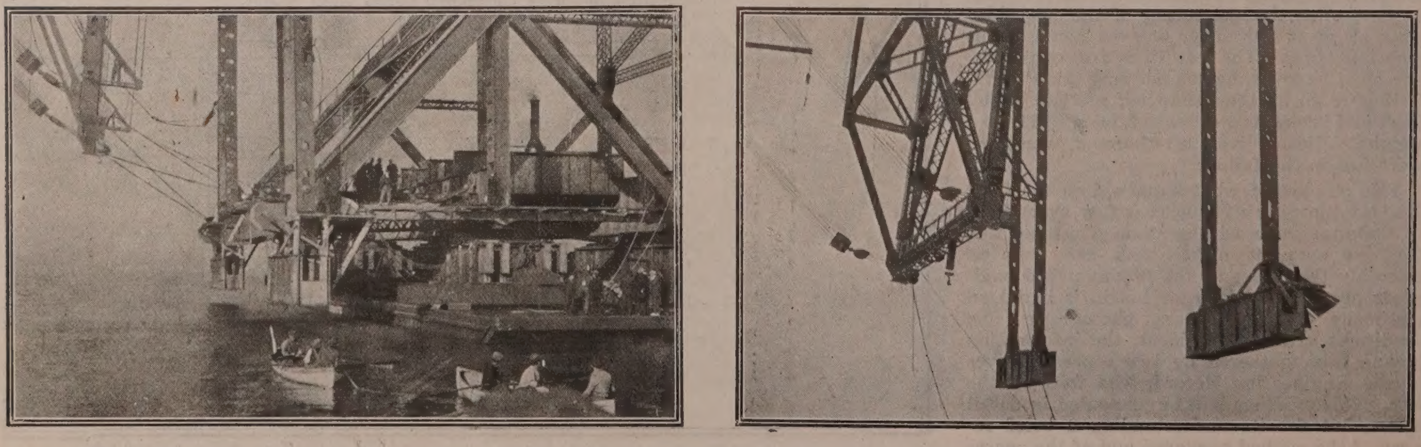


Copyright, 1916, by International Film Service

REMARKABLE PHOTOGRAPH, LOOKING WEST, SHOWS SOUTHWEST CORNER UNDER WATER BEFORE OTHER THREE HAD LEFT THEIR STIRRUPS AND CONFIRMS THEORY OF MOMENTARY DIAGONAL SUPPORT AND CRUMBLING OF NORTH HALF OF WEST, OR FAR TRUSS



THE TWO STIRRUPS THOUGHT TO HAVE CARRIED DOUBLE LOAD—LEFT IS AT NORTHWEST CORNER, RIGHT ONE AT SOUTHEAST, SHOWN VERTICAL AT LEFT OF VIEW ABOVE—PLATFORM WRECKAGE IS FROM SPAN—NOTE BENT LINK OPPOSITE IT



LEFT, SUSPENDER LINKS ATTACHED TO SPAN; RIGHT, SAME PAIR AFTER ACCIDENT—FAR HANGER IN BOTH VIEWS WAS FIRST TO JUMP OUT

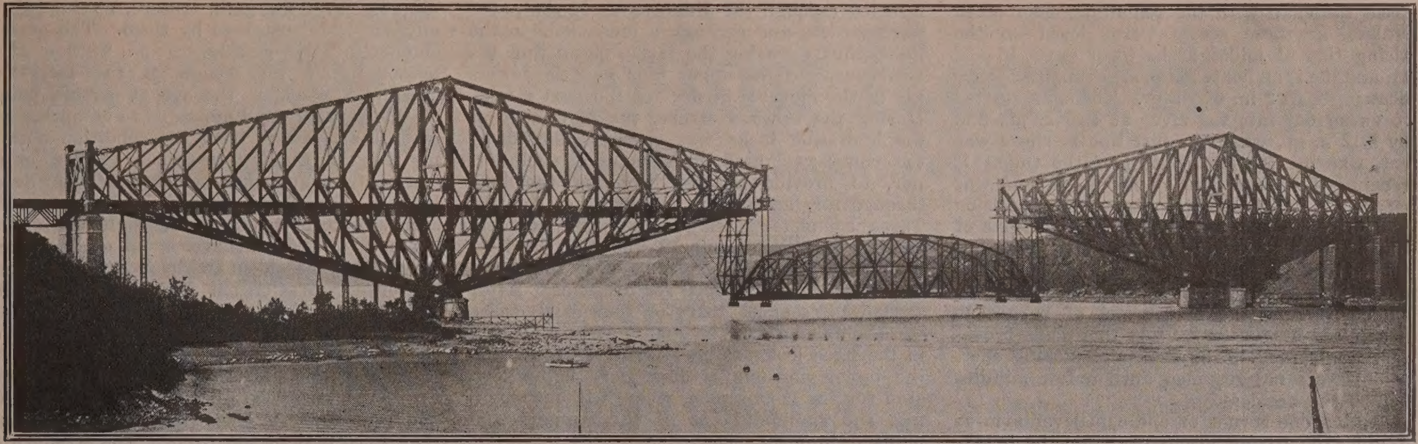
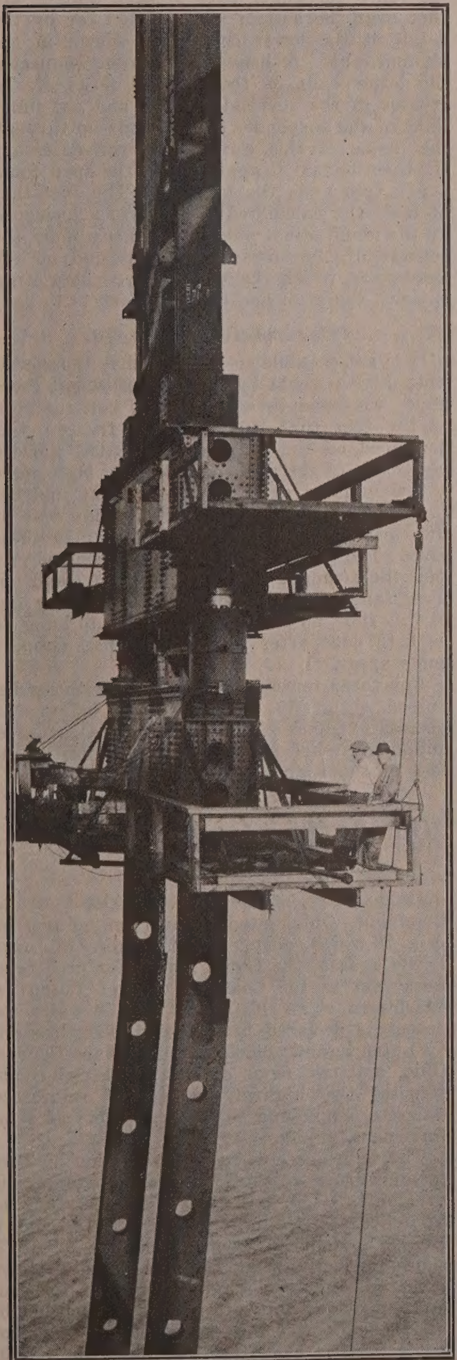
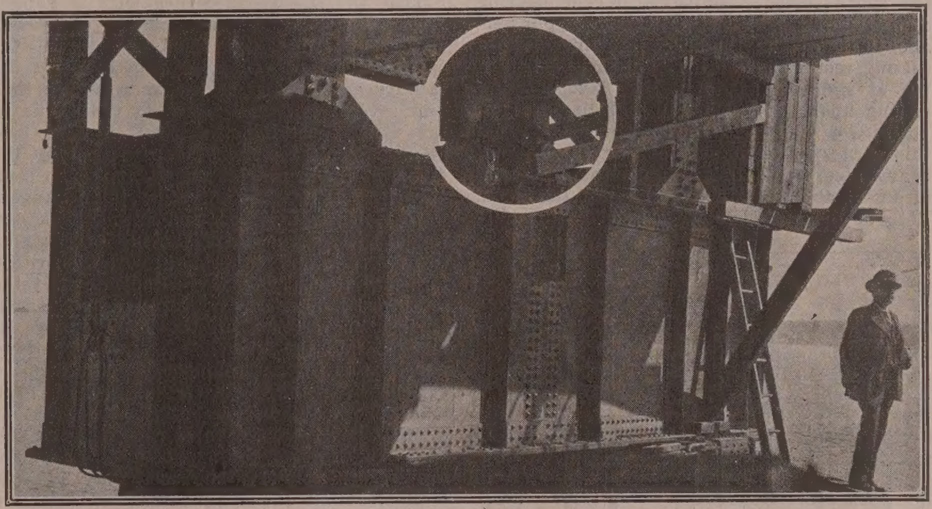


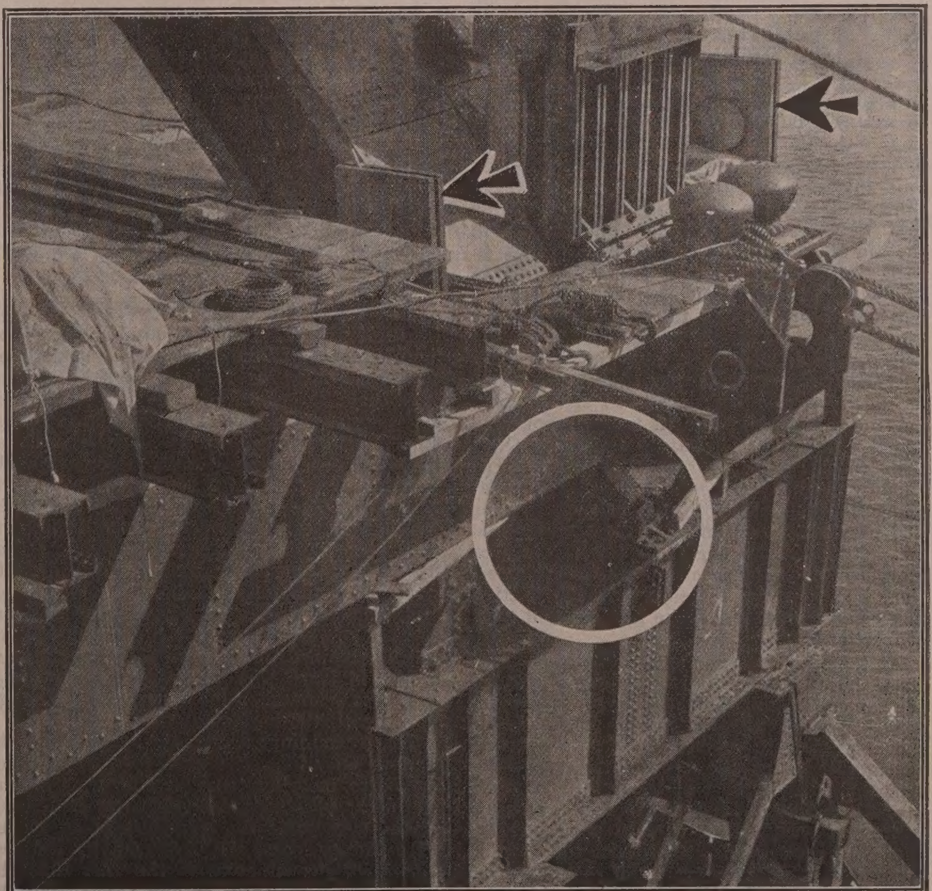
Photo by the Standard, Montreal

THIS PHOTOGRAPH, SNAPPED ALMOST AT THE MOMENT OF COLLAPSE, SHOWS EXACT CONDITIONS IMMEDIATELY BEFORE THE FAILURE



A PAIR OF JACKING GIRDERS, BEFORE PLACING OF SPAN—UPPER ONE IS RAISED AND LOWERED BY JACKS SEATED ON LOWER ONE—NOTE PIN HOLES



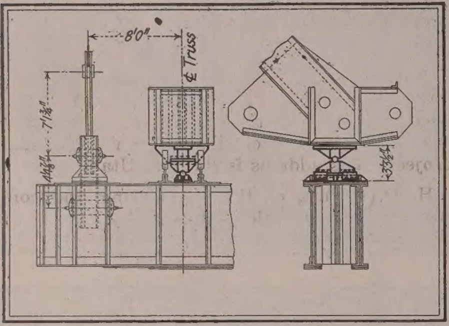


ABOVE, INSIDE AND BELOW, OUTSIDE OF STIRRUPS, BEFORE FLOATING FROM FALSEWORK

Circles show suspected cast rocker bearings; arrows, stub suspender links. Note that left link comes up through box girder of span from the span with the remaining floor steel. Valves in these scows were closed on the rising tide at midnight between Sept. 10 and 11, and the span floated at 3.53 a. m., the barges drawing 8 ft. 2 in. of water. The span started to swing out into the river at 4.40 a. m., and by 5.12 a. m., when the last line to shore was cut, was in complete control of the tugs. It reached the bridge site at 6.55 a. m. and was moored in position with remarkable precision and in very short time. The hanging links of the lifting mechanism had been completely attached by 8.35, and in about 40 minutes jacking operations were started, which raised the span sufficiently for the last group of barges to float clear by 9.30 a. m. At this point breakfast was served to the men, and jacking operations were not resumed until a few minutes before the accident.

Taking one corner of one cantilever arm as a unit, the lifting mechanism may be briefly described as follows:

First, on blocking on the outer end of the top chord rested a universal rocker bearing composed of a base casting bearing a pin parallel to the axis of the bridge, an intermediate casting resting on the first pin and bearing a pin at right angles to it, and a top casting resting upon the second pin and directly supporting a short, heavy box girder. From this girder on each side of the chord hung heavy steel plate links supporting a second girder at approximately the level of the track. Both of these girders were fixed with reference to the raising of the span, and did not change relative position during lifting operations. On the lower girder rested a pair of hydraulic jacks tested to a capacity of 1250 tons apiece. Upon these jacks was carried a third and movable box girder similar to the first pair. Passing through diaphragms in the movable and in the lower fixed girder on each side of the truss were suspender links in 30-ft. lengths having pin holes on 6-ft. centers and extending down to the level at which the center span was floated in. After this span was moored in place, the lower ends of these suspender chains were pinned to stub links at the corners of the suspended span. Each pair of these stub links in turn supported a fourth box girder similar to the other three upon which rested a corner of the span. The support at this point was identical with that above the top chord of the cantilever arm, and provided, by means of three castings and two pins at right angles to each other, for movement of the suspended span in any direction, due to wind pressure, without putting any bending stresses on the hangers and their connections.



DETAIL OF SUSPECTED STIRRUP

At the time the span came to a bearing on these hangers, which are plainly shown in the accompanying photographs, pins were inserted through the diaphragm holes of the movable girders resting on the jacks and through holes at the top of the suspender links. The jacks were at the bottom of their stroke. To raise the span, two hydraulic pumps on each cantilever arm were started, supplying pressure at 4000 lb. per square inch to the jacks through a system of control valves which made it possible to regulate the relative movement of the corners and ends of the span very accurately. When the jacks had reached the top of their 2-ft. stroke, pins were inserted through the diaphragms of the lower fixed girders and through a lower hole in the links, thus releasing the jacks, permitting the withdrawal of the upper pins and the lowering of the movable girder for the next stroke. During the upward stroke, the movement of the hydraulic jacks was closely followed by two counterweighted screw jacks at each corner, to provide against dropping the load through any accident to the hydraulic piping. Three complete jacking cycles, the first requiring 15, the second 12 and the third 10 minutes, were completed to release the scows before work was stopped for breakfast. After work was resumed, three or four more cycles were completed and the span was held by pins in the fixed lower girders while the jacks and the upper movable girders were being lowered for the next stroke, when, without warning, the span slid out of the hangers and plunged into the river.

Evidence to Support Explanation of Failure

That the southwest corner left its hanger first is indicated by the testimony of eyewitnesses, one of whom went down with the span, several of whom were in boats in the vicinity and looking at the span at the time and several of whom were on the banks of the river observing the span through field glasses. This testimony is confirmed by the fact that the southwest hanger remained comparatively still, while the other three hangers were violently agitated, and swung back and forth, with a movement having components transverse to and longitudinal with the bridge, for some time. This would indicate that the southwest hanger was not affected by the subsequent movements of the span before it plunged into the river, while the other three were. It is further confirmed by the positive evidence from the very remarkable photograph which shows this corner beneath the water at a time when the other three corners were still above the level of the supports. This photograph also confirms the testimony of eyewitnesses that the span turned over toward the west in disappearing.

That the span broke up in the manner indicated by reason of the fact that it was supported for a short space of time on the southeast and the northwest corners is evidenced by eyewitnesses who saw:

1. A parting of the top chord of the west truss at the second panel point from the south end.
2. A crumpling of the top chord of the west truss at the north end.
3. A pulling apart of the eyebars in the bottom chord of the east truss at the north end.

Photographs Important Evidence

All of these statements are confirmed by the photograph of the plunging span published herewith. They are further confirmed by the fact that the southeast and the northwest hangers sustained more damage than the other two, and that the platforms on the jacks at the top of these hangers were more completely broken up by swinging than those around the other two. The violence with which the southeast hanger tore loose from the southeast corner of the truss is evidenced by the fact that its westerly suspender bar was considerably stretched, and that this is the only hanger in which the girders were thrown to any extent out of level. Also the lower pin, half of which remained in place on this hanger, was broken in two. The hanger diagonally opposite also showed some inclination, though slight, with the horizontal.

The remaining deductions, regarding the manner in which the east lower corner of the north mooring truss became warped and the blocks by which this truss was pulled out of the way while the span was being placed were broken loose, are borne out by the testimony of eyewitnesses to the fact that the truss swung violently to and fro, as did the hangers on this arm, and by the warping of the truss and the breaking loose of the falls.

So far as could be observed, without going minutely over the main trusses, no damage of any sort was sustained by them. The normal camber of the cantilever and anchor arms before taking the weight of the suspended span was visible to the eye at certain points on the structure and appeared to be unchanged after the accident from the condition obtaining on the Sunday previous. There is no testimony of any pieces of steel or rivet heads having sheared off and fallen. Locomotive cranes were operated on the structure out to the ends of the cantilever arms on the afternoon of the accident without producing any motion or vibration not discernible during the preceding week—all this, in spite of the fact that for a short time during the collapse of the center span the west truss of the north cantilever and the east truss of the south cantilever must have been under at least 100 per cent greater load from this span than they were designed to carry. The strength of the hanger mechanism is fully attested by the fact that all four hangers are intact, as may be seen in the photographs. The fact that the inner suspender bars of each hanger are bent near the bottom is accounted for by the detail of the lower connection shown in the photographs. A heavy box girder connected the lower ends of the inclined posts of the trusses of the suspended span, and the inner links of the suspender chains came up through the inside of this girder. It was necessary for them to tear it apart before the span could break free from the hangers. The fact that at least the calculated friction was developed by the longitudinal pins in the shoes under the corners of the span is well attested by the manner in which the last three corners hung on until the span had broken apart.

Other Theories Considered

It is not possible to suppose that the southwest stirrup could have been pulled out from under the span in any manner, both because of the fact that such a great friction was developed on the other pins, because a close inspection of the mooring lines had been made a few minutes prior to the accident and because the upward motion of the span was at the time loosening instead of tightening these lines. The photographs also prove conclusively that the members of the truss itself could not have failed and thus caused the slipping out of this shoe, as the truss continued to hang on at both ends after its members had actually come apart.

For these reasons, as well as for those discussed editorially, this journal is led to suspect the failure of the intermediate cast-steel supporting shoe as the primary cause of the loss of the span.

Ohio District Court Finds Luten Patent Invalid

Judge Sater, of the U. S. District Court at Columbus, Ohio, handed down an opinion on Aug. 28 which concurred in the ruling of Judge Lewis against the Luten patent for arch reinforcement in the Colorado case of Luten vs. Washburn, et al. This later suit, in which the patent is declared invalid, had been brought by Luten against officials of Delaware County, Ohio, and two firms of contractors who constructed two highway bridges of reinforced concrete, employing the Kahn system of reinforcement.

The Court accepted the explanation by Professor Turneaure that three prior patents, one to Hyatt, U. S. patent No. 206,112; one to Thatcher, U. S. patent No. 617,615, and a British patent to Hyatt, No. 289 of 1877, showed exactly what Luten claimed to have invented—that is, "a reinforcing bar for concrete, provided with projections of such height and spacing that the space between adjacent projections is more than ten times the height of the projections."

It was held that the mere fact that these former patents failed to point out this relationship did not permit the idea to be monopolized by anyone who might point it out later.